POWER

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The Night Before Christmas

FOR the last six months, John, the assistant engineer and fireman, had started for the plant with the regularity of a clock. It was noon, but cloudy, and a wet snow blew in his face. This would probably promise a dark night, which would require all the street lights burning. Christmas Eve would mean nearly every house lighted from attic to cellar and the lights in the three churches going full-blast. A Christmas Eve quite different from those in former days was ahead.

It was the first Christmas away from home. Chances were, however, that there would be little time to indulge in reveries. "If the boss has finished putting in those flues in the large boiler, I can get along all right," thought John. "But he had some wiring to do besides the job I finished this morning, and the chances are that he did not touch the flues. Small chances of him being around this afternoon, as he told me to run the plant to-morrow morning, because he was going home for Christmas."

When John arrived at the plant, conditions were not any better than expected. His first thoughts were to quit right there, take the train and try somewhere else. He was sick of working from noon till 1 a.m. for 12 dollars per week with an occasional morning run, and helping the boss do wiring in the bargain. It would, however, be the first time that he was a quitter, and so he decided to stick it out.

There were a few hours before time to start up, and this time had to be used to the best advantage in getting everything ready for a long run and a heavy load. The boiler to be used was the older and smaller of the two. After a thorough cleaning of the flues and starting a new fire, the steam was soon up to the required 80 lb. The heaviest part of the run would be from 7 to 10 o'clock; so in shoveling out the coal for the night's run, the best coal was left for that period. A few times the telephone rang calling for lights, but John thought better not to be too much in a hurry to start.

Finally, with steam up and with plenty of water in the boiler and the tank, the run was started. For the first few hours the load kept steadily increasing, but there was time enough to eat a bite and smoke a pipe. After that John gave most of his attention to the boiler. At 7:30 he ventured to clean the fires and pumped the water up as high as was considered safe. The steam was up, but the lights grew dim so the belt must be slipping. After tightening the belt, a hurried look at the engine, filling the oil cups and adjusting the rheostat, he was back at the boiler and the real battle began. The only thought now was to keep the steam at the 80-lb. mark.

The plant consisted of an 80-horsepower engine and direct-current dynamo and needed little attention. However, one of the main bearings had been giving trouble of late under normal load, and this caused some worry.

It was impossible to leave the boiler room, and only by firing very lightly and pumping in water only when the steam was going up was it possible to keep up steam. At 8:15 the load seemed about as high as it possibly could go, but the grates were so full of clinkers that loosening with the slice bar would have but little effect.

John realized that he would have to clean his fire. Already he was wringing wet with perspiration. By cleaning first one side and then the other and doing it quickly, the loss in pressure was slight, but the man behind the shovel felt the effects of the heat and hard work. Would he be able to keep this up, would the belt carry the load and would the engine bearing keep cool? Just then the telephone bell rang. At first he did not pay attention, but finally took down the receiver. An angry voice at the other end of the line, probably from a gentleman who had been reading in his cozy library, informed him that the lights were too dim to read by. John hung up the receiver with a bang without answering. Several times that evening the telephone bell sounded, but the wires might as well have been crossed for all the answer that came from the plant.

Until 9 o'clock things went along after a fashion, but the hardest part was over. Several times he wished that the wind would blow down the line or that the ministers would stop administering to their flocks.

Again the fire had to be cleaned, and being almost exhausted, John commenced to trust to good luck and cared little whether the plant ran any longer. "There is no reason why folks could not go to bed at 9 o'clock on Christmas Eve," he mumbled.

The load began to drop; a glance in the engine room showed that the old engine had been faithful to its reputation and John knew that the battle was nearly over.

Long before the required time of 12:30 he gave the wink to show that the plant would stop in ten minutes. No doubt there would be a complaint, but little did he care.

After lighting his lantern and closing the throttle, he sat down a moment to think. What a night it had been. What beastly weather it was outside! There was no use going home and coming back at 5 o'clock. Might as well stay here.

He rolled into some blankets at the side of the boiler and tried to sleep, but although almost exhausted, it was impossible. There was the thought of home, the girl he had left behind, the popping off of the boiler, the hard floor and the question if Big Ben would go off at the right time.

The next day John told the boss he was going to quit. Why? Because he was going to school to learn the English language so people could not say that he was not worth as much as other men because it was hard to get along with a foreigner.

Contributed by J. H. Van Arkel, Scranton, Penn.

A Machineless Air Compressor

SYNOPSIS—Air is compressed by falling water to a pressure of 118 lb. Automatic regulation is obtained by utilizing the air pressure built up in the compressor chamber. Excessive air pressure is automatically relieved by means of an escape pipe running from the air chamber to the surface. Water for compressing the air is taken from a river and discharged into it again, one mile downstream.

Obtaining compressed air up to 4,000 hp. capacity without using either steam- or motor-driven or other moving machinery, although not new, is a distinctive feature in the operation of the Victoria copper mine of the Victoria Mining Co., of Ontonagon County, Michigan.

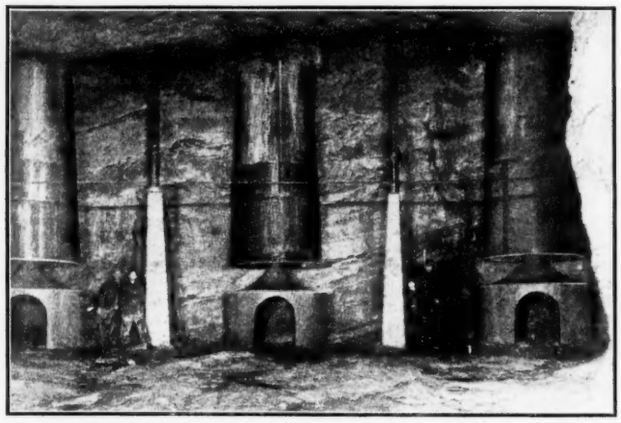


FIG. 1. CONCRETE SPREADING PIERS BELOW DISCHARGE TUBES

About 82 per cent. of the actual power of the falling water through tubes is transferred to compressed air under a pressure of 118 lb. This air is delivered to the hoisting engine, stamp-mill power units and to the mine proper practically dry and at the temperature of the water. The system is practically automatic, and as there are no moving parts, the upkeep is very low. Water for compression purposes is taken from the Ontonagon River and, after passing through the system, is returned to it at a point about one mile downstream. A forebay is secured by constructing a 300-ft. concrete dam 10 ft. high, across the river. The water is diverted into a canal in which it is carried 400 ft. downstream, where there is a net drop of 71 ft. to the level of the river. At this point the machineless power house is situated. Three 5-ft. cement shafts, each sunk 330 ft. through rock, end in the roof of a large compression chamber. Conical steel tubes project from the concrete shafts 16 ft. into this chamber and flare to 7 ft. 4 in. diameter at the outlet end. Directly under each discharge tube is a concrete spreading pier, built on the floor of the compressing chamber. This feature is shown in Fig. 1.

At the tube end the compressing chamber is 21 ft. high and 57 ft. wide. These dimensions are carried 50 ft. toward the other end of the chamber and then it narrows to 18 ft. in width and 26 ft. in height for the remainder of the 281 ft. At the end of the chamber a 10-ft. high tunnel is constructed for 40 ft., thence it goes into an inclined shaft to the surface, through which the water is discharged to the river.

Air is compressed in the compression chamber, which is constructed in solid rock and has an air capacity between the water line and the roof of 80,264 cu.ft. As shown in Fig. 2, from the water level in the forebay to that in the chamber is 343 ft. and the water-power head from the forebay to the tail-water level is 72 ft., thus giving an air-pressure head of 271 ft.

From the upper and right end of the chamber a tunnel is made at about a 30-deg. incline and running into the main discharge water tunnel. This carries a 24-in. air pipe that conveys air to the mine and stamp mill and also a 12-in. blowoff pipe. The space not occupied by the pipes is filled with concrete. The lower end of the blowoff pipe is at the water level in the compression chamber 12 ft. below the roof (Fig. 3) and extends 5 ft. above the water level in the tailrace.

At the upper end of each of the three concrete shafts is a steel tube that extends 6 ft. above the bottom of the forebay. In this tube is a telescoping head, shown in detail in Fig. 2, the pipe end of which moves freely up and down in the pipe projecting from the concrete shaft. This arrangement permits of moving the head so that it can be brought above the water level in the forebay, thus cutting off all water from flowing to the compression chamber, or it can be lowered below the surface of the water.

This header is 10 ft. diameter and is designed to be below the water level when the system is in operation. Connected to the header are eight 7-in. vertical tubes that project above the water level and are the air intakes.

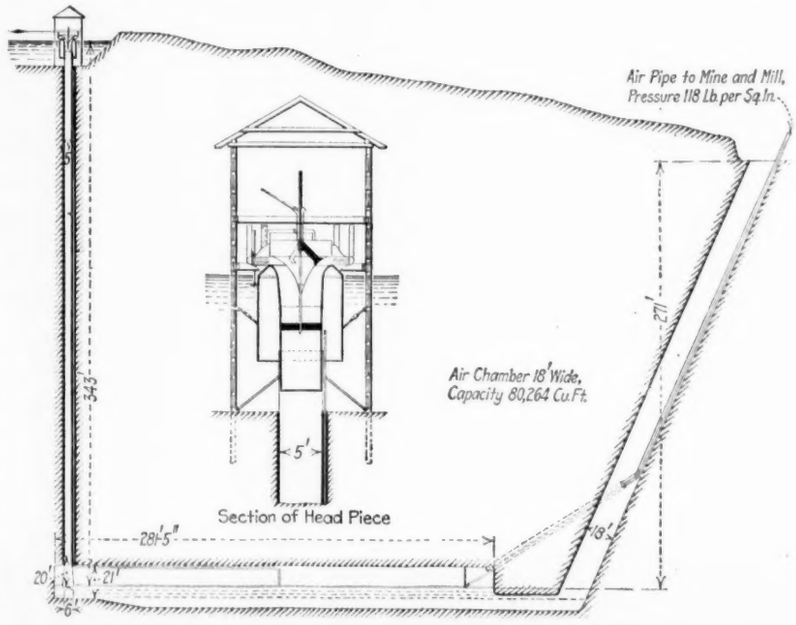


FIG. 2. DIAGRAM OF COMPRESSOR SYSTEM

When water flows into the head, when submerged, the downward flow produces a suction that draws air in through the atmospheric tubes into the column of water and goes with it to the compression chamber.

The volume of air entering the head is controlled by adjusting the space between a concave and a convex casting (see enlarged head, Fig. 2). This is accomplished by moving the concave piece either up or down by means

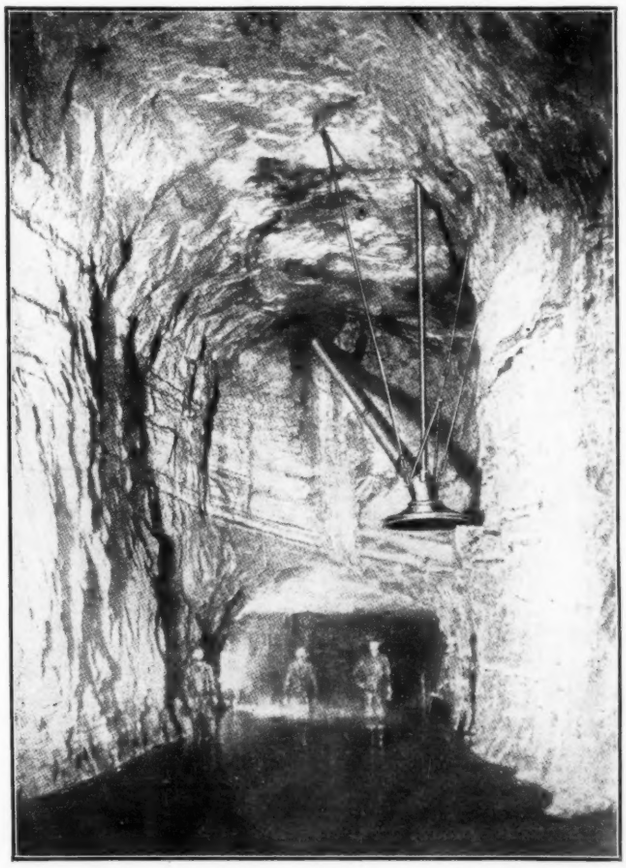


FIG. 3. LOWER END OF BLOWOFF PIPE IN COMPRESSOR CHAMBER

of an adjusting screw, thus opening or closing the space between the castings and cutting off as much air as is desirable. When putting the system into operation, the head piece is lowered by turning the adjusting screw and capstan nut until the lower rim of the upper casting is a few inches below the level of the water in the forebay, when water will rush into the opening between the two cone-shaped castings and into the shaft. This causes a partial vacuum to form, drawing in air through the air-inlet pipes, and it descends in small bubbles with the water and is gradually compressed in the downward journey to the bottom of the shaft. The heat of compression is absorbed by the water during its fall.

Striking the conical cement pieces at the bottom of the shaft, the water and air are sprayed in all directions and flow along the compression chamber toward the outlet end. As the flow is slow, the air has sufficient time to separate and rise through the water to the upper portion of the chamber. The air pressure forces the water down until it reaches the lower end of the 12-in. escape pipe, Fig. 3. This action uncovers the pipe and allows air to rise in it and mix with the water, which forces the water out of the upper end of the pipe. As the surface air thus escapes, the water will not be forced any lower in the chamber by further accumulation of air so long as the main 24-in. air-supply pipe is not opened.

When the main air supply to the mine units is opened, the water rises in the chamber until the lower end of the escape pipe is sealed, thus filling it with water and preventing the escape of air. This condition exists until another surplus of air forces the water below the bottom of the escape pipe, when water and air are again blown out through the escape pipe, as shown in Fig. 4. The main body of water that is free of air flows up the 18-ft. incline discharge shaft and discharges to the tailrace leading to the river.

An air pressure of 118 lb. is maintained at the stamp mill, with a constant water height of 271 ft. in the shafts. The pressure varies only when the compressor is overworked, but as the compression chamber is large, as high as 12,000 cu.ft. of air can be drawn off per minute for a period of 18 min. with not more than a 5-lb. drop in pressure.

Automatic air regulation is obtained by means of an air-pipe connection from the air chamber to the inverted float of the lower conical casting. When sufficient air pressure has accumulated in the compressor chamber, it passes up through this pipe and, discharging into the inverted float, lifts the rim of the lower conical casting

FIG. 4. WATER AND AIR DISCHARGING FROM RELIEF PIPE

and prevents the further flow of water past the air inlets, thus stopping the further compression of air. The float is equipped with an adjustable valve that automatically permits of air leakage. As soon as the air pressure in the compression chamber below is relieved, the conical casting falls and the flow of water past the air inlets is resumed.

The main air pipe from the compressor chamber is extended on the surface for a distance of about a mile. The air is used to operate mine drills, pumps, a hoisting engine (a new 32x72-in. twin hoisting engine is ready to start) with a hoisting speed of 1,500 ft. per min. About 500 hp. is required at the stamp mill, which is about 500 ft. from the compressor.

The outlay for this compressor system was about $22 per horsepower not including the cost of the dam and canal, which was about the same. The cost of this compressed-air power is about $2.25 per horsepower-year, allowing 5 per cent. interest on the first cost. The plant was designed by C. H. Taylor, of Montreal, Canada.

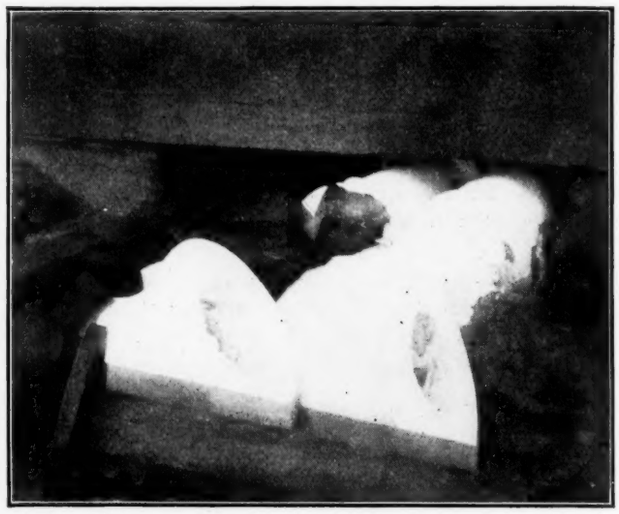


FIG. 5. FROSTED EXHAUST PIPES OF HOISTING ENGINE USING COMPRESSED AIR

This installation it is understood is one of six in the world and the second one in the United States. The hoisting engine used up to the present time is a regular twin Corliss hoist using air at 118 lb. The exhaust is at a temperature of about 40 deg. below zero. The frosted condition of the exhaust pipe is shown in Fig. 5.

Control for Hydraulic Elevator Pump

A unique scheme is used in the design of the apparatus for controlling the high-duty elevator pumping engines at the South Bend plant of the Singer Manufacturing Co. The accumulator is in the cabinet building approximately 600 ft. from the pumps. The common method of tiller rope for the control of the chronometer valve was considered as inadequate and dangerous on account of the distance between the accumulator and the pumps. The following device was worked out and gave very satisfactory results: A Mason balanced pump governor was installed in the high-pressure steam line for each of the two high-duty pumping engines. These governors were provided with hydraulic cylinders the piston working against a compensating spring. When the pressure is relieved on the underside of the piston the spring closes the valve.

A 1½-in. line was carried from the underside of the piston to the outlet on a three-way cock located close to the accumulator. A domestic-service water connection and a waste connection were made to the other two openings on the cock. Position No. 1 allowed service water to flow through the 1½-in. pipe to the underside of the piston of the pump governor cylinder, raising the piston against the spring and opening the steam supply to the pump. In position No. 2 of the plug cock, the service water was shut off and the water from the 1½-in. line and governor cylinder being allowed to waste to the sewer, relieved the pressure on the underside of the pump-governor piston, the spring on the top of the piston seating the valve.

The plug cock was operated by the following device: A bracket with roller was attached to the side of the accumulator, the roller traveling in a vertical line. Two rocker arms with shafts and bearings were provided. These bearings were attached to a channel iron, which was bolted to the building wall at the side of the accumulator. One arm was set near the top of the accumulator travel and one near the bottom of the travel. These arms were in parallel and connected by means of a link. Each was counterweighted and provided with an extension to prevent the roller on the accumulator running off. The rocker arms were substantially keyed to the shaft in each case. The lower shaft was provided with a keyed connection to the plug of the three-way cock. The total travel of each arm was 90 deg.

Near the end of the up-travel of the accumulator, the roller engages the top lever, moving it through 90 deg. The bottom lever being connected by the link to the top lever, a travel of 90 deg. for the bottom lever would result, shutting off the city water supply and opening up the waste connection so that the valve on the pump supply closes. The counterweights hold the levers and plug cock in this same position until the roller reaches the lower lever, pushing it back 90 deg. shutting off the waste connection and opening up the (city) water pressure on the underside of the governor piston. This opens the valve and starts up the pump.

The distance between the two shafts determines the distance of travel on the accumulator. An adjustment was provided so that the distance between the shafts could be changed to prevent the accumulator shaft from wearing to a shoulder. This arrangement satisfactorily solves the pump control for a hydraulic elevator plant where the accumulator is placed at a distance from the pumps, as is necessary in a plant where elevators are widely distributed.

Loss of Heat Energy in Steam Pipes of power plants is often underestimated. Care is exercised in guarding against loss of energy in electrical distribution systems and against loss by direct leakage of steam or water, and against undue loss of pressure between the boilers and the prime movers, but comparatively little attention is usually given to the balance sheet of heat, as contained in the fuel and as utilized by the prime movers. While the losses through incomplete combustion of fuel and incomplete absorption of heat are often susceptible of material reduction, careful attention to the heat-distributing system, beginning with the steam outlet of the boiler and ending with its feed-water inlet, will pay large returns upon the time and money invested. While the greatest savings are of course to be secured in insulating high-pressure live steam lines where the high temperatures prevail, the low-pressure lines and low-temperature lines are well worth the attention and expense to keep them well insulated. The cost of the insulation is oftentimes repaid twice over in a single year, after which the saving is of course net profit.

The Cold Test of Oil shows the temperature at which it ceases to flow or when it passes from the liquid to the congealed state. It is sometimes important that the oil should be fluid at low temperatures, and in these cases it is desirable that the cold test should be known.

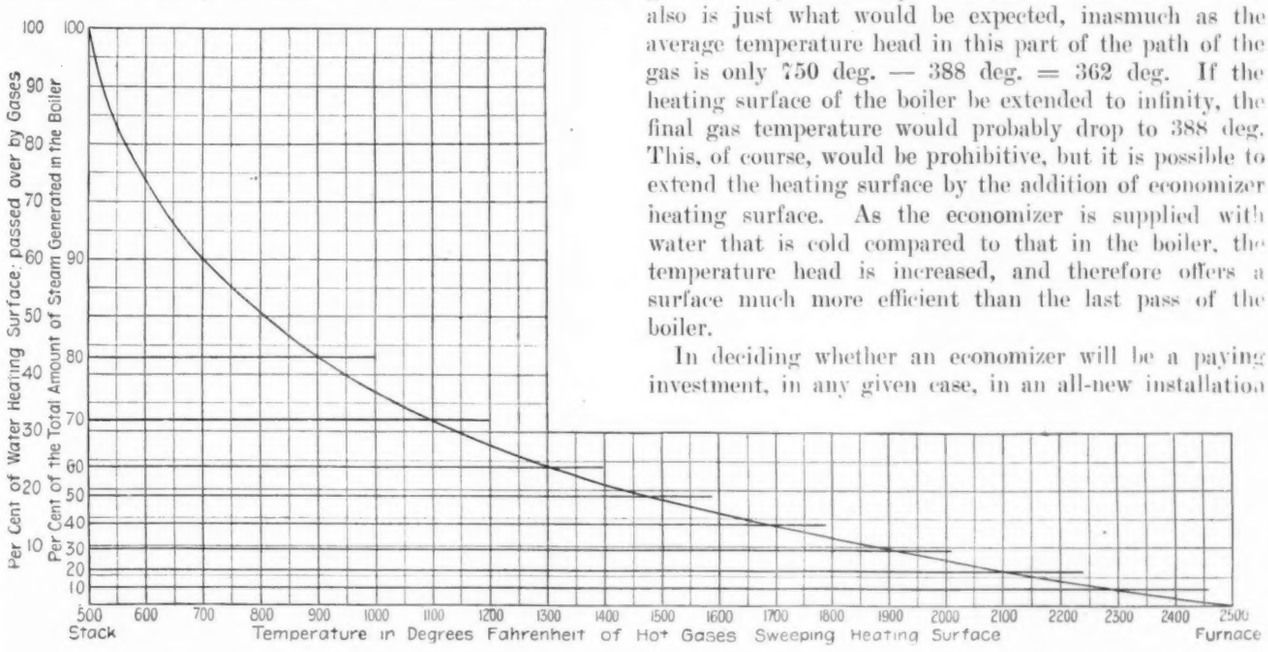
Relationship of Boiler Heating Surface to Economizer

By M. C. Sherman

SYNOPSIS—Consideration is given to the proper relation of the economizer heating surface to that of the boiler, the heat flow from the gases to the boiler and economizer, the saving obtained by the installations of economizers and the cost of such installations.

Power plants in districts where fuel is comparatively inexpensive are notable for the absence of economizer installations. There has been a decided trend in the last few years, however, toward the use of economizers in large central stations.

The use of economizers in all kinds of plants will depend ultimately on whether it will show a good return on the extra money invested. The writer feels that the value of the economizer is not generally appreciated because the relationship between the heating surface of a boiler and the heating surface of an economizer to serve that boiler is not often properly considered or proportioned. For example, all the steam and water in a boiler having good circulation is at a temperature depending on the pressure carried. At 200 lb. it is about 388 deg. F., and if the gases leaving the boiler are 500 deg. F. and the gases striking the first heating surface from the furnace are 2,500 deg. F., then the relationship between gas temperature and heating surface of the boiler passed over by the gas is established and the total amount of steam generated is shown on the curve taken from "Steam" (Babcock & Wilcox Co.)


Per Cent of Water Heating Surface passed over by Gases
Per Cent of the Total Amount of Steam Generated in the Boiler
100
90
80
70
60
50
40
30
20
10
500 600 700 800 900 1000 1100 1200 1300 1400 1500 1600 1700 1800 1900 2000 2100 2200 2300 2400 2500
Stack
Temperature in Degrees Fahrenheit of Hot Gases Sweeping Heating Surface
Furnace

RELATION BETWEEN GAS TEMPERATURE, HEATING SURFACE PASSED OVER AND STEAM GENERATED

Referring to the curve, it will be seen that starting from the furnace, the transfer of the heat from the gas to the steam is very rapid, as indicated by the percent. of the total amount of steam generated in the boiler, and that this rapid transfer of heat takes place through a relatively small proportion of the total heating surface. For instance, the gases, in dropping from a temperature of 2,500 deg. to 1,500 deg., pass over only about 18 per cent. of the total heating surface, and there is generated by this 18 per cent. of heating surface 46 per cent. of the total amount of steam generated. This is, of course, natural, inasmuch as in this time the average temperature head between the gas and the steam and water is 2,000 — 388 deg. = 1,612 deg. Referring to the curve again, from this point—that is, from 1,500 deg. on down to 500 deg.—the heat transfer becomes markedly less and less rapid. For instance, from 100 deg. to 500 deg. the gases pass over 63 per cent. of the total heating surface and generate only about 25 per cent. of the total steam. This also is just what would be expected, inasmuch as the average temperature head in this part of the path of the gas is only 750 deg. — 388 deg. = 362 deg. If the heating surface of the boiler be extended to infinity, the final gas temperature would probably drop to 388 deg. This, of course, would be prohibitive, but it is possible to extend the heating surface by the addition of economizer heating surface. As the economizer is supplied with water that is cold compared to that in the boiler, the temperature head is increased, and therefore offers a surface much more efficient than the last pass of the boiler.

In deciding whether an economizer will be a paying investment, in any given case, in an all-new installation the question is, how much of the total heating surface to be installed shall be boiler and how much economizer surface. For example, to generate 90,000 lb. of steam per hour of 200 lb. gage, feed-water temperature 200 deg. F., four boilers might be installed, discharging flue gas at about 500 deg. F. and operating with a total efficiency of 70 per cent. with coal averaging 13,000 B.t.u. as fired. Under these conditions 10,230 lb. of coal per hour would be required.

With the addition of an economizer which will reduce the gas to 375 deg. and raise the water to 250 deg., the temperature of the gas leaving the boiler to the economizer would be about 10 deg. less than without the economizer, because less fuel would be burned on account of the added efficiency of the economizer and less gas would pass through the same area in the boilers and would be reduced to a somewhat lower temperature. With the economizer

it would be necessary to burn only 9,700 lb. of coal, or a saving of 530 lb. per hr., a little over 5 per cent. of that required to do the same work with boilers only. An economizer to do this work properly would have approximately 5,100 sq.ft. of heating surface and cost about $5,500 installed.

Suppose we used four boilers with a grate surface and steam-relieving capacity equal to the first, but discharging their gases at 600 deg. by shortening the travel of the gas, in other words, by reducing the boiler-heating surface. An economizer to reduce the gas to 375 deg. and raise the 200-deg. feed water to approximately 300 deg., would contain about 9,200 sq.ft. of heating surface and cost installed about $9,500, or $4,000 more than the one with the larger boilers.

Assuming that the larger boilers had 20,000 sq.ft. of heating surface, in order to reduce the gas to 500 deg., those with reduced heating surface discharging gas at 600 deg. would require about 14,300 sq.ft., a reduction of 5,700 sq.ft. at about $1.25 per sq.ft., or approximately $7,000 installed.

Therefore the assumed reduction in boiler-heating surface and the greater economizer surface would produce the same over-all efficiency as the larger boilers and smaller economizer surface. The same amount of steam would be generated, the same amount of fuel burned, the same sized furnaces and practically the same amount of heating surface used and the same over-all efficiency obtained in both cases, except that in the second case a greater proportion of the total heating surface would be in the economizer and there would be a saving of approximately $3,000 on the installation.

It is therefore necessary to properly proportion the amount of boiler and economizer heating surfaces to secure the best results from a given investment.

There are many other factors besides relationship of heating surfaces, the one point intended to be brought out in this letter.

There are numerous cases where, through force of custom and without proper thought, the wrong boilers have been bought. In some cases too efficient boilers, costing too much, were unable to show a satisfactory return on an extra investment for economizers, whereas a properly proportioned boiler in relation to the total heating surface of the plant, with the addition of an economizer, would have shown a gratifying return and more efficiency than the plant with the efficient boilers without economizers.

In properly proportioning boiler and economizer heating surface the same practical points must be borne in mind as in any boiler installation—that the concentration of salts in bad feed water will not be so great as to cause priming, and that the furnace shall be ample for the best combustion conditions. The important thing, however, is properly proportioning the heating surface of the boiler and economizer, bearing in mind that economizer surface is more efficient than the last pass of boiler, costs less at first and costs less to operate.

Practical Talks on Controllers--Current-Limit Type*

SYNOPSIS—The principle of operation of a series-contactor switch is explained, in which only one coil is used to obtain the proper functions of the switch. The operation of an automatic starter employing series contactors is also described.

The starting mechanism of direct-current motors is continually becoming more and more important. When motors were first used for industrial purposes, they were of relatively small sizes and conditions were such that they had to be started only two or three times a day. Furthermore, the speed adjustment of motors did not enter into the problem nor did motor reversal.

With frequent starting, stopping and reversing required, with quick stopping a necessity in many cases and with operations that require motors to duplicate definite cycles of operation, the automatic motor starter and controller has become a necessity. In fact, in many cases it is the controller that is given the most detailed consideration, because it makes certain applications possible.

The rapid development of automatic control has been materially aided by the design of a series contactor. The function of a series switch is twofold. First, it regulates the time at which the resistance in the motor should be cut out of circuit, and secondly, it cuts this resistance out of the motor circuit. The actual closing of the switch is governed entirely by the current through the armature of the motor. This same current also passes through the series-operating coil which actuates the contactor.

Two or more of these series contactors with the necessary starting resistance make a simple current-limit auto-

FIG. 1. CURRENT-LIMIT AUTOMATIC MOTOR STARTER

matic motor starter. A starter of this type is shown in Fig. 1. The switches operate one after another, each one short-circuiting a part of the starting resistance. When all the switches have operated, the starting resist-

*The material in this article was contributed by M. D. Goodman, of the Electric Controller and Manufacturing Co.

ance is entirely short-circuited and the motor is getting full line voltage.

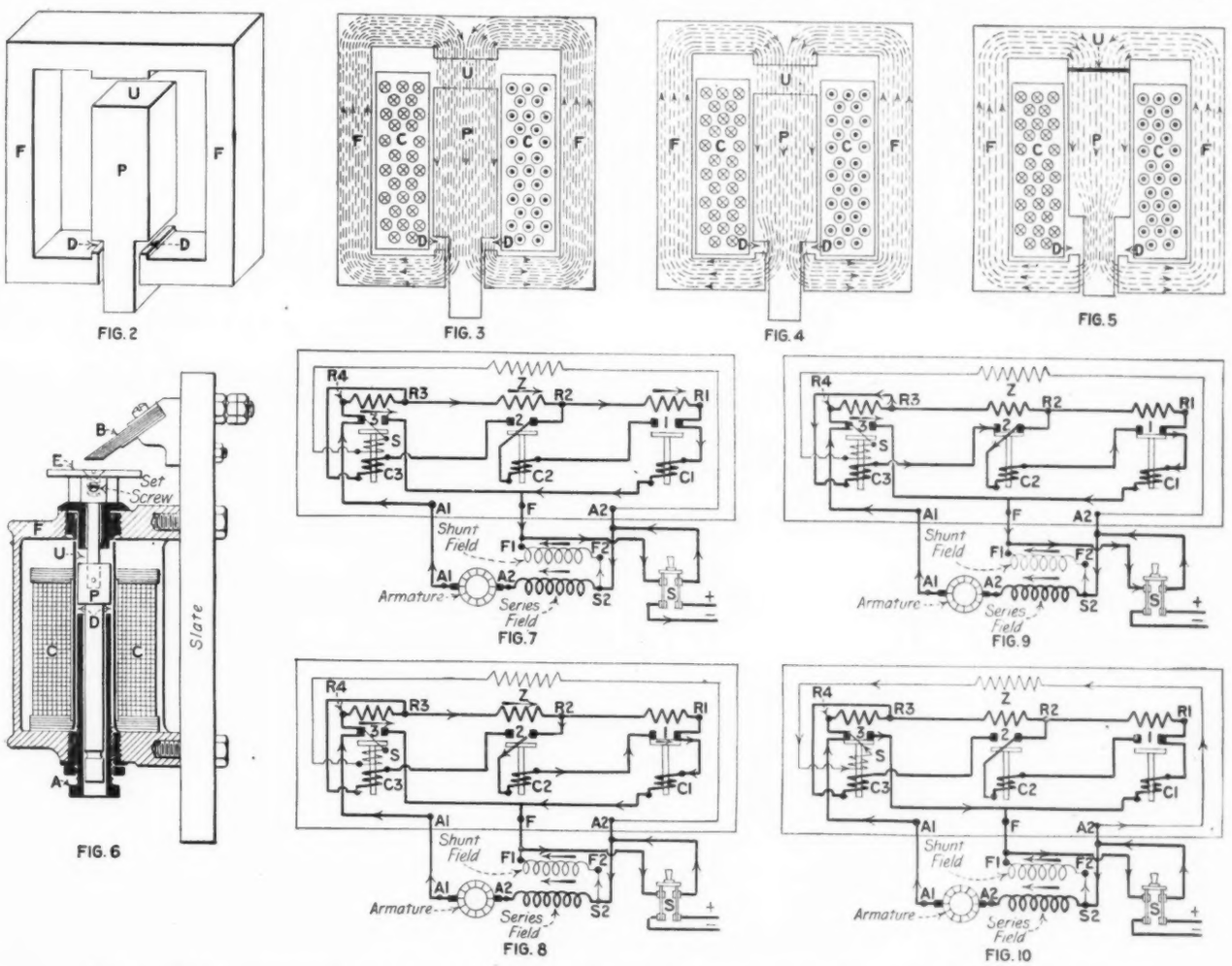
It is well known that with an ordinary solenoid the more current flowing through its coil the harder the plunger will be pulled up. In the series contactor, however, the plunger does not move when the current in the contactor coil is larger than a certain amount, but it does lift when the current is less than this amount. As it is important to know what causes this peculiar action, the following explanation is given:

Fig. 2 represents a rectangular iron frame F and plunger P. The plunger is narrower at the bottom than at the top, and the narrow part of it fits loosely in an opening in the bottom of the frame. There are two air gaps D between the plunger and the bottom of the frame and one air gap U between the plunger and the top of the frame.

Next assume that a coil is placed around the plunger P, as shown in Fig. 3, where the circles represent the cross-sections of the wires of the coil C. The dots represent current flowing toward the reader, while the crosses represent current flowing down through the plane of the paper. If a heavy current is caused to flow through the coil, magnetic lines will stream through the plunger P, across the air gaps D and through the narrow part of the plunger P back through the frame F and across the air gap U, as indicated by the arrowheads. The reason some of the lines go through the air gaps D is that the narrow part of the plunger P is saturated, or in other words, it cannot carry any more magnetic lines. Therefore, some of the lines are forced through the air gaps when a large current flows through the coil. The magnetic flux in the air gap U causes an upward pull on the plunger, but the weight of the plunger and the downward pull of the magnetic lines in the air gaps D hold the plunger down.

Fig. 4 is the same as Fig. 3, except that less current is flowing through the coil, with the result that there are not so many lines of force passing through the plunger and the frame. Most of these lines can now pass through the narrow part of the plunger, but there are still a few in the air gaps D. The downward pull on account of the lines passing through this air gap, is now less than it was before, but this pull and the weight of the plunger are still enough to hold the plunger down.

Fig. 5 shows the current in the coil still less, consequently the magnetic lines are fewer than in Fig. 4. Practically all of them are passing through the narrow part of the plunger, so that there is now very little downward pull at the air gaps D. There is, however, still a heavy upward pull at the top air gap, which is enough to lift the plunger, as shown in Fig. 5. The foregoing is exactly what happens in the operation of the series contactors shown in the automatic starter, Fig. 1.



FIGS. 2 TO 10. EXPLAINS THE OPERATION OF AN ELECTRIC CONTROLLER AND MANUFACTURING CO. AUTOMATIC MOTOR STARTER

Fig. 6 is a cross-section of an Electric Controller and Manufacturing Co.'s series contactor, with a coil C, a magnetic frame, or case F and a plunger P, just as shown in Figs. 2 to 5. The bottom of the plunger is smaller than the top, like the plunger in the preceding figures, but it is round instead of square. The magnetic lines through the air gap U try to lift the plunger when the current in the coil is larger than a certain amount but the magnetic lines in the air gap D hold it down. When the current becomes less than a given value, practically all the magnetic lines pass through the small part of the plunger and there is very little downward pull at the air gap D, but the pull at the air gap U is enough to lift the plunger, which forces the contact plate E against the two laminated copper brushes B. When the contact plate touches the brushes, it short-circuits a part of the starting resistance.

The series contactor to be commercially practical must be adjustable. The adjustment is accomplished by changing the length of the air gap D by screwing the adjusting plug A in or out of the case F. To increase the current at which the contactor is to operate, the air gap D is lengthened. The maximum setting for which this type of contactor may be set to operate is about four times the minimum adjustment. This feature indicates that the series type of contactor will adapt itself to widely divergent operating conditions.

Operation of Current-Limit Type Controller

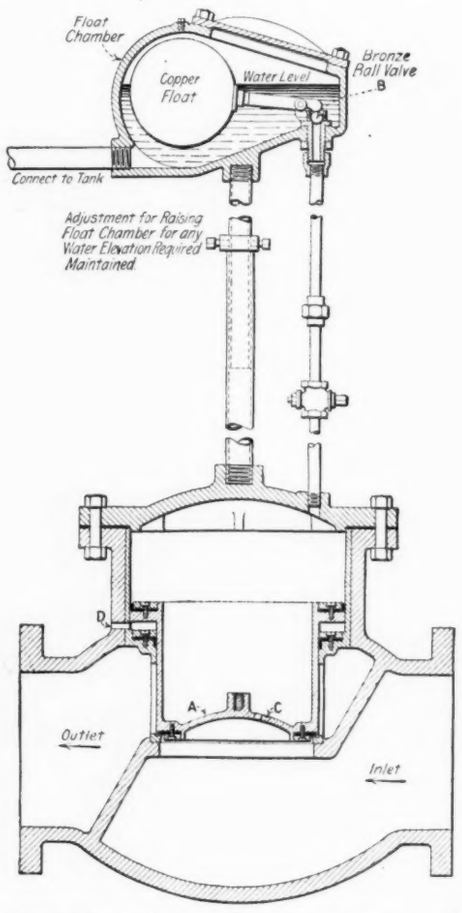
Fig. 7 shows the wiring connections of an automatic motor starter, using series contactors, the operation of which is as follows: With the line switch S closed, current will flow from the positive terminal through the armature, all of the starting resistance, coil $C1$ and to negative side of the line; current will also flow through the shunt-field winding, as indicated by the arrowheads. The motor starts, and as it gains speed, the current flowing through the armature becomes smaller, consequently the current flowing through coil $C1$. When the motor current is reduced to a certain amount, this coil will close contact No. 1, short-circuiting the section of starting resistance between $R1$ and $R2$ and energizing coil $C2$, as shown in Fig. 8. Current now flows from the positive terminal through the armature, the starting resistance between $R4$ and $R2$, the operating coil $C2$, the brushes and contact plate on No. 1 contactor, the operating coil $C1$ and to the negative side of the line, as indicated by the arrowheads.

The short-circuiting of the resistance between $R2$ and $R1$ increases the motor current, which prevents contactor No. 2 from closing as soon as coil $C2$ is energized; but the motor continues to gain speed and the current is again reduced. When it reaches the same amount as before, contactor No. 2 operates and short-circuits the resistance between points $R2$ and $R3$, as shown in Fig. 9. Current now flows through the armature, the resistance between $R4$ and $R3$, the operating coil $C3$, No. 2 contact plate, the operating coil $C2$, No. 1 contact plate, the operating coil $C1$ and to the negative side of the line, as shown. As before, the motor current is increased, which prevents coil No. 3 from closing its contactor as soon as it is energized; but the motor gains speed, and when the current is again reduced to the proper value, contactor No. 3 operates and closes its contact, as indicated in Fig. 10. Current now flows from the positive through the motor and contactor No. 3 directly to negative side of the line, as indicated. All the operating coils and the starting resistance are now short-circuited and the motor is getting full line voltage.

Since the operating coils are short-circuited, practically no current passes through them, and contactors 1 and 2 drop open, but contactor 3 is held closed by its shunt-holding coil S. This is a small shunt coil in the top of the contactor No. 3, which is not strong enough to operate the contactor, but is strong enough to hold it closed after the series-operating coil has closed it. If the motor is running very lightly loaded, the motor current may become so small the series coil would not hold the contactor closed, and hence the shunt-holding coil is used. The shunt-holding coil is generally used on automatic starters or automatic controllers for machine tools; it is usually omitted on reversing controllers for series motors, in which case the series-operating coils of one or more contactors remain in circuit.

Automatic Cushioned Float Valve

Any valve that will automatically maintain a uniform water level in heaters, tanks, etc., is a big advance over any kind of hand regulation. Such a valve is manu-



CUSHIONED CONTROLLING FLOAT VALVE

factured by the Golden-Anderson Valve Specialty Co., Pittsburgh, Penn.

In the illustration is shown a sectional view of their automatic cushioned controlling float valve. The upper

portion of the valve body is lined with bronze down to and including the seat; the large piston valve *A* is also of bronze and is fitted with rings to take up wear and to prevent the metal parts from coming in contact.

The illustration shows the valve in a closed position. When the water level in the tank, heater, etc., lowers, it also lowers in the float chamber of the valve, and therefore the float lowers, allowing the ball auxiliary valve *B* to open and water above the piston *A* to enter the float chamber. At the same time the initial water pressure under the piston *A* opens the main valve and supplies water to the tank. This is because the unbalanced condition on the two sides of the piston *A* is relieved with the opening of the valve *B*.

Just as soon as the predetermined water level has been reached in the vessel being supplied, the water level in the float chamber will also have reached a level sufficient to raise the ball float and close the auxiliary ball valve. Water then flows through the port *C* in the piston *A* and accumulates above it, and subsequently shuts off all water supply by closing the valve, because the area on the upper side is greater than that on the under side of the valve piston. A cushion is provided for the opening of the valve by the water above. It is cushioned in closing by air that is drawn in through the port *D* in the side of the valve body.

The float chamber is supported by a telescoping stand, as shown in the illustration.

George Peabody College Power Plant

By James H. Browne

SYNOPSIS—A college power plant designed to supply electrical energy and heat to the buildings of the institution. The main units at present comprise marine-type boilers and steam turbines.

In Nashville, Tenn., there is under construction a group of buildings that will constitute the George Peabody College for Teachers. Five buildings are completed, but the central power station is planned to serve a total of 54 buildings. The power equipment is in the basement of the Manual Training Building.

A high degree of centralization has been effected in the design of this plant, which furnishes energy for light and power, and also low-pressure steam for heating, intermediate-pressure steam for cooking and for labora-

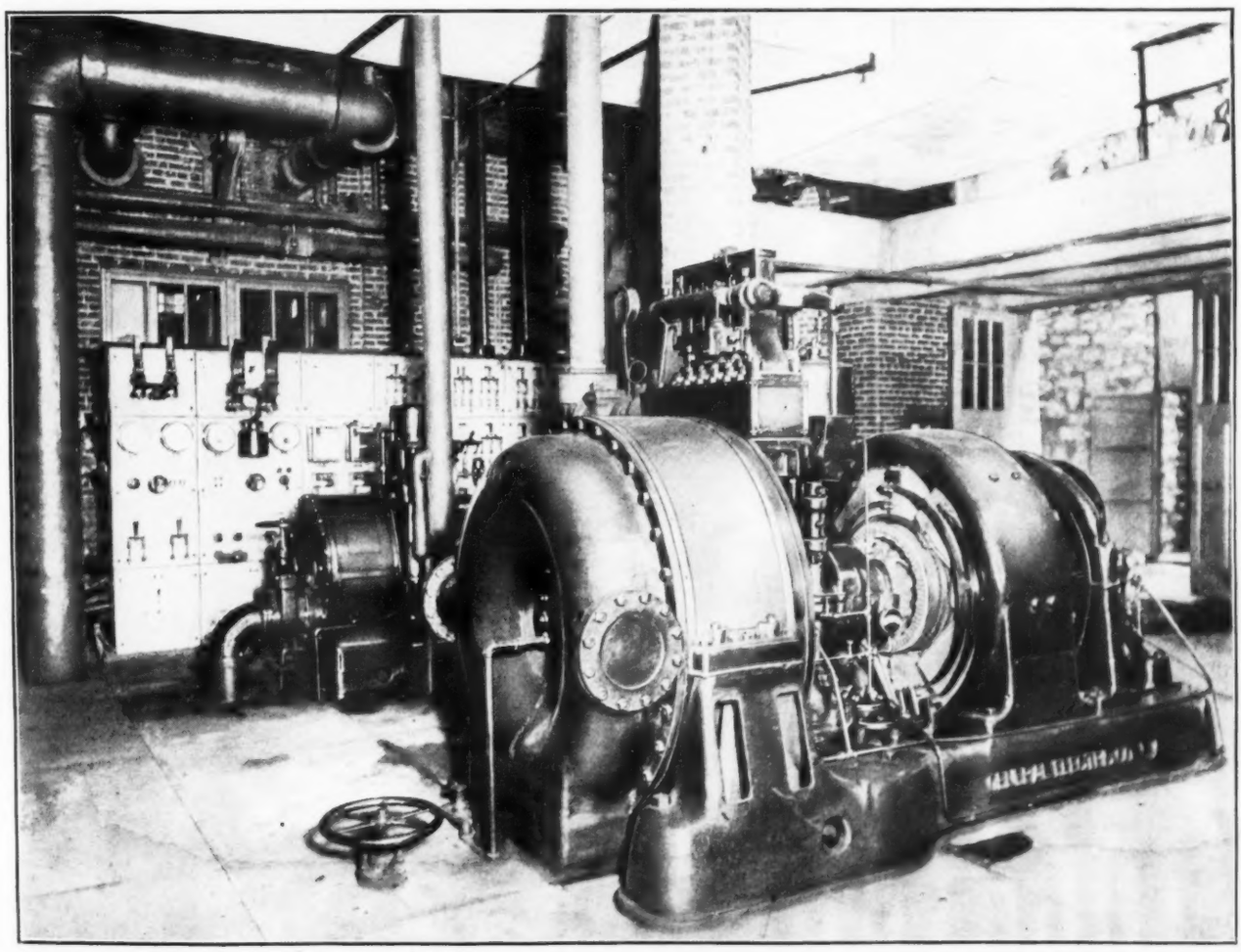


FIG. 1. TURBINE UNITS AT THE GEORGE PEABODY COLLEGE

tories; vacuum for cleaning purposes, compressed air for operating thermostats controlling the heating system in each building, and for laboratory apparatus, hot water for lavatories, cold water for general service and high-pressure water for fire service. All the service lines, together with the electric conduit, are carried in tunnels to the various buildings.

Only a portion of the total power equipment has been installed, but the basement has been so arranged that units can be added as the number of completed buildings is increased. There are now in operation, two boilers of the vertical marine type, each having 2,000 sq.ft. of heating surface, furnishing steam at 125 lb. pressure. Stokers of the automatic underfeed type serve the boilers. Each stoker has 42 sq.ft. of active grate surface, or 1 sq.ft. per 47.5 sq.ft. of boiler-heating surface.

The stokers are supplied with air and the gases of combustion are exhausted by a dual system of forced and induced draft. The forced-draft apparatus consists of a motor-driven automatically controlled fan discharging into an underground masonry duct having openings connecting to the air box of each stoker. The induced-draft apparatus consists of a motor-driven automatically controlled fan connected to an overhead steel smoke breeching and discharging into an underground masonry duct that extends outside of the building and to the chimney.

Forced-Draft Apparatus

The draft apparatus is of sufficient capacity to supply air for 2,400 hp. and is controlled by an automatic furnace system. Each stoker is capable of operating continuously at 50 per cent. overload, and 75 per cent. overload for two hours without the emission of smoke. The forced-draft fan is of the double-inlet multivane type, connected to a variable-speed motor by a silent-chain drive, and furnishes air at 1½ oz. pressure at each ashpit. The induced-draft fan is of the single-inlet multivane type, and is connected similarly to the forced-draft fan.

Coal is conveyed from the bins on an overhead trolley track, there being two ball-bearing trolleys, each carrying a self-righting self-dumping coal bucket.

Ashes are conveyed along the same overhead track to the ash bin and are raised from this point by means of a telescopic hoist, provided with buckets that travel at a speed of 200 r.p.m.

All the buildings in the college are served with hot water from the central plant. It is heated in a closed heater, the steam connections being so arranged that the heater will operate either on intermediate-pressure steam or on exhaust steam in summer when the exhaust from the turbines is not needed for heating.

A feed-water heater of ample size heats the boiler-feed water and at the same time acts as a storage for the heating returns, which vary on a central heating system, especially when buildings are turned on or off. Fig. 2 is a view of the pumping apparatus.

The exhaust steam from the turbines and auxiliaries is utilized to heat the various buildings, and when the amount is not sufficient, steam is taken from the high-pressure main through a reducing valve set to maintain the required pressure in the heating mains. The returns pass through a condenser having a capacity for an equivalent of 200,000 sq.ft. of direct radiation, thence through a 10-in. suction strainer to either of two vacuum pumps. The speed of each pump is governed to maintain any desired degree of vacuum on the building heating returns.

All high-pressure mains are covered with 85 per cent. magnesia. The 6-in. and larger mains have covering 1½ in. thick, and smaller mains have covering 1 in. thick. All flanges are covered with removable fire felt with 10-oz. canvas cover sewed on. Intermediate-pressure mains, high-pressure drips and return pipes are covered with sectional covering 1 in. thick, and of 70 per cent. asbestos fiber and 30 per cent. fireproof material. The smoke flue is covered with two ¾-in. layers of air-cell blocks, wired on, over which a 1½-in. asbestos-cement felting is applied and finished smooth.

All the buildings are piped for vacuum-cleaning service from the central plant. This consists of a horizontal

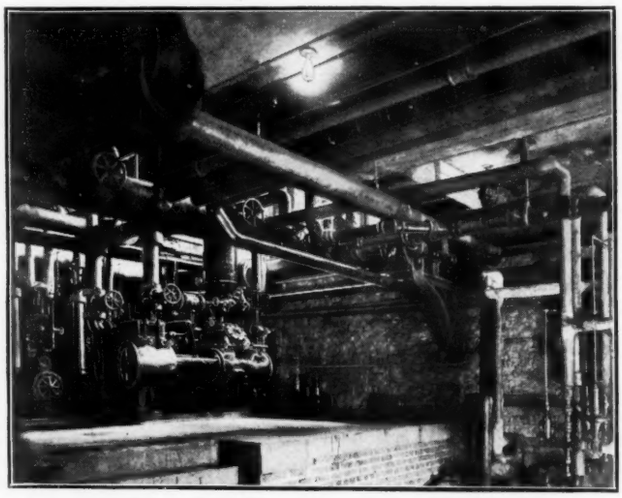


FIG. 2. PUMPS FOR HANDLING HOT AND COLD WATER

steam-driven vacuum pump having a total free air displacement of 960 cu.ft. at a speed of 130 r.p.m. The machine is provided with one set of dust tanks (wet and dry) having a total capacity of 42 cu.ft.; 97 per cent. of the dust is intercepted in the dry tank by centrifugal action and the balance in the wet tank. The plant is capable of operating simultaneously twelve 12-in. vacuum sweepers maintaining a vacuum of not less than 12 in. with 100 ft. of hose on each sweeper.

Air is compressed by two steam-driven compressors each capable of compressing 50 cu.ft. of air per minute with a constant pressure of 35 lb. per sq.in.

Electricity for light and power is obtained from two turbo-generators, the generators (Fig. 1) being three-wire, direct-current 125-150 volt machines. One is of 75-kw. and the other of 300-kw. capacity. The smaller turbine operates at approximately 3,300 r.p.m. and the larger at 1,500 r.p.m., with a steam pressure of 125 lb. at the throttle.

The plant has been so designed that the engineer may keep himself informed of the cost of operation. The necessary instruments have been installed so that he may also know the cost of the various factors that enter into the total cost. The overhead coal trolley is provided with scales, and all coal and ashes may be weighed. The boiler-feed water is metered and recorded by a V-notch integrating meter. Indicating and recording gages are mounted on the gage board. There are also mounted in the boiler room, to check the economy of stokers and boilers,

recording and indicating instruments as follows: A feed-water temperature recorder, a flue-gas temperature recorder, an induced-draft recorder and a forced-draft recorder. By the use of these instruments the engineer always has his plant practically under test conditions and any drop in economy will be apparent by reference to the various charts. The electrical output is also recorded by graphic meters. They are arranged to show the energy used for power and light separately, and also to show the combined station load.

Getting at the Cost of Power

By C. W. Whiting*

SYNOPSIS—Points out the difficulties met when determining the cost of power and suggests means of overcoming them.

Much has been said about power costs, and yet usually, when the question arises, there is much discussion without any satisfactory results. There are several reasons why this is so, and among them are the following:

In the first place, the phrase itself carries a confusion of ideas because it is not specific. It does not specify which cost or which power is referred to. There are many kinds of cost. For instance, there is the coal cost, which includes only the cost of coal; then there is the operating cost, which includes the coal cost together with the cost of attendance, supplies and repairs; and there is the total cost, which includes the operating cost together with the interest and depreciation charges. Again, there are many kinds of power. For instance, there is the power generated in an engine cylinder; then there is the power that is measured on the switchboard after it has been converted into electric power; and there is the power taken from the motor shaft after it has been transmitted, transformed and reconverted into mechanical power. If there were only these three kinds of cost and three kinds of power, there would be nine costs of power; but there are more kinds of each, and it is necessary to specify what is meant when discussing the subject.

In the second place, the subject is quite complicated and may have unknown elements even in its simplest form. It might be an easy matter to determine the coal cost of the electric power measured on the switchboard, because that could be ascertained simply by dividing the cost of coal consumed during a given period by the kilowatt-hours

DESIGNED BY C. W. WHITING FORM A
BOSTON, MASS.

FOR _____

DISBURSEMENTS FOR POWER, LIGHTING AND HEATING

DATE	LABOR	FUEL	WATER	TOOLS AND SUPPLIES	REPAIRS			TAXES INSURANCE	ELECTRICITY	
					BOILERS &C.	ENGINES &C.	DISTRIB. SYSTEMS		FOR POWER	FOR LIGHT
1	2	3	4	5	6	7	8	9	10	11

FIG. 1. EXPENDITURES FROM THE CASHBOOK ARE ENTERED ON THESE FORMS MONTHLY

generated during that period; but if any of the steam generated was used for heating the buildings or for industrial processes, part of the cost of coal should be charged to these latter items.

In the third place, when the question arises as to the cost of power, there are often conflicting interests. A central power plant may be offering power in competition with the isolated plant; salesmen of power-plant equipment may be offering their equipment for the production

DESIGNED BY C. W WHITING FORM ____
BOSTON, MASS.

FOR _____

TOTAL COST OF POWER, LIGHT AND HEAT

FOR THE YEAR ENDING _____

ITEM	1 - LABOR	$
"	2 - FUEL	
"	3 - WATER	
"	4 - TOOLS AND SUPPLIES	
"	5 - REPAIRS TO BOILERS ETC	
"	6 - " " ENGINES, "	
"	7 - " " DISTRIBUTING SYSTEMS	
"	8 - TAXES AND INSURANCE	
"	9 - ELECTRICITY BOUGHT FOR POWER	
"	10 - " " " LIGHT	
"	11 - TOTAL OPERATING EXPENSE	$
"	12 - INTEREST ON COST, AT 5%	$
"	13 - DEPRECIATION ON COST, AT 5%	
"	14 - TOTAL FIXED CHARGES	$
"	15 - TOTAL OVER ALL COST	$

FIG. 2. THE YEARLY TOTAL CHARGES ARE ENTERED ON THIS FORM

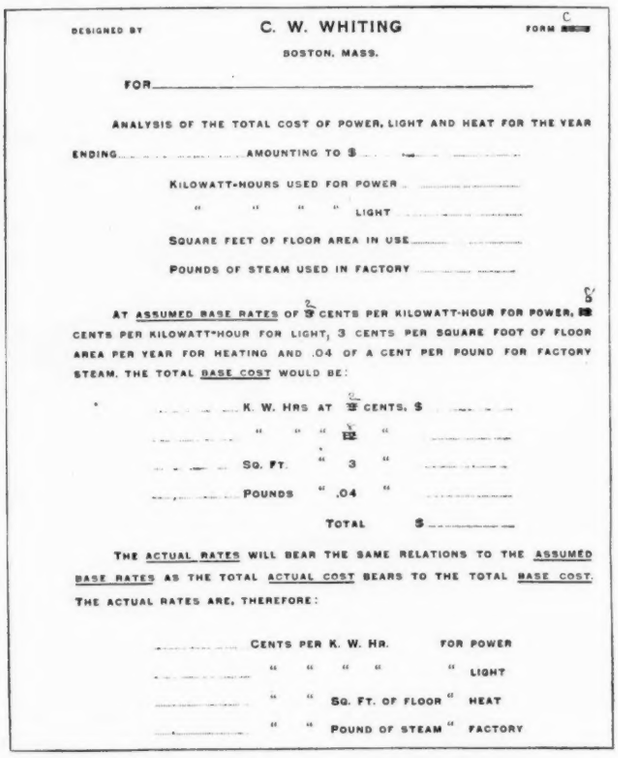
of power by isolated plants; and the operating engineer may desire, for personal reasons, either to purchase power or generate it at the factory or works.

Usually when the question arises, there is almost certain to be an unfortunate lack of information regarding the subject. The users of power are generally manufacturers of one sort or another, and they often know the exact cost of each item of labor and each item of material in connection with their regular business, but they seldom if ever know what they are actually paying for power or for light and heat. This may be because they are not conversant with the details of power-plant operation or because their regular business seems of paramount importance to them or because the expenditures for the three items of power, light and heat are so intimately associated.

The foregoing remarks show why the cost of power is such an unsatisfactory subject and indicate what should be done about it. A more thorough understanding of the subject should be had by those who undertake to handle it, and more complete operating data should be collected by the power plants. In almost all cases, the real cost of power is a part of the cost of power, light and heat and it is rather difficult to separate the one from the

*Consulting Engineer, Boston, Mass.

others. It is a comparatively simple matter to determine what the combined cost of power, light and heat has been for any given period, but unless that cost is separated in some way into the amounts that are chargeable to power, to light and to heat and then reduced to the equivalent rates per unit of power, light and heat, it is impossible to say whether that combined cost is high or low or to determine whether or not it could be reduced by making other arrangements. It would, of course, be possible to keep the accounts and the physical records in a shape that would enable a person perfectly familiar with the subject to determine the costs of power, light and heat exactly, but such accounts and records would be more complicated



DESIGNED BY C. W. WHITING FORM C
BOSTON, MASS.

FOR _____

ANALYSIS OF THE TOTAL COST OF POWER, LIGHT AND HEAT FOR THE YEAR ENDING _____ AMOUNTING TO $ _____

KILOWATT-HOURS USED FOR POWER _____
" " " " LIGHT _____
SQUARE FEET OF FLOOR AREA IN USE _____
POUNDS OF STEAM USED IN FACTORY _____

AT ASSUMED BASE RATES OF 2 CENTS PER KILOWATT-HOUR FOR POWER, 5 CENTS PER KILOWATT-HOUR FOR LIGHT, 3 CENTS PER SQUARE FOOT OF FLOOR AREA PER YEAR FOR HEATING AND .04 OF A CENT PER POUND FOR FACTORY STEAM, THE TOTAL BASE COST WOULD BE:

_____ K. W. HRS AT 2 CENTS, $ _____
_____ " " " 5 " _____
_____ SQ. FT. " 3 " _____
_____ POUNDS " .04 " _____
TOTAL $ _____

THE ACTUAL RATES WILL BEAR THE SAME RELATIONS TO THE ASSUMED BASE RATES AS THE TOTAL ACTUAL COST BEARS TO THE TOTAL BASE COST. THE ACTUAL RATES ARE, THEREFORE:

_____ CENTS PER K. W. HR. FOR POWER
_____ " " " " " LIGHT
_____ " " SQ. FT. OF FLOOR " HEAT
_____ " " POUND OF STEAM " FACTORY

FIG. 3. THE FINAL ENTRY FORM

than the average manufacturer would care to keep. The next best thing is to gather the several items of cost together into one lump sum and then to charge the parts of it to power, light and heat by proportion. With this end in view, the writer has used certain forms, which are shown herewith and which are named *A*, *B* and *C*, Figs. 1, 2 and 3 respectively. They are used as follows:

Once a month all expenditures that are chargeable to the supply of power, light and heat should be drawn off from the cashbook and entered in the proper column of Form *A*, Fig. 1.

Column 1 should show the year, month and day of payment.

Col. 2 should show all wages paid to regular attendants at the power plant, unless part or all of their time is chargeable to Col. 3.

Col. 3 should show the cost of all coal and other fuel, together with all freight, teaming, unloading and handling charges necessary to lay the fuel down in the boiler room.

Col. 4 should show only the cost of water that is used for boiler feed.

Col. 5 should show the cost of all such supplies as oil, waste, packing, boiler compound, tools, etc.

Col. 6 should show both labor and material costs of repairs to boilers, flues, chimney, feed-water heater, feed pump, and piping connecting the same; except when the labor is supplied by the regular attendants.

Col. 7 should show both labor and material costs of repairs to engines, generators, condensers and piping connecting the same; except when the labor is supplied by the regular attendants.

Col. 8 should show both labor and material costs of repairs to the distributing systems, whether they be piping for steam or water or wiring for electric light or power; except when the labor is supplied by the regular attendants.

Col. 9 should show all taxes that are chargeable directly to the power plant, all boiler insurance and all fire and liability insurance that are actually chargeable to the power plant.

Col. 10 should show the cost of electricity purchased for power.

Col. 11 should show the cost of electricity purchased for light.

At the end of each month all columns should be footed up, and the footings for twelve consecutive months should be added together and carried to Form *B*, Fig. 2, as indicated. Items 12 and 13 of Form *B* should be based upon the total original cost of the plant. Item 15 of Form *B* should then be carried to the second line of Form *C*, Fig. 3. Then, from the physical records, there should be entered on Form *C* the kilowatt-hours used for power during the twelve months, the kilowatt-hours used for light during the twelve months, the square feet of floor area heated and the pounds of steam used during the twelve months for factory processes. The process after that is definitely indicated by Form *C*.

The forms referred to are on 8½x11-in. paper and are punched for a ring binder.

Do Belts Slip as Supposed?

By S. B. Richey

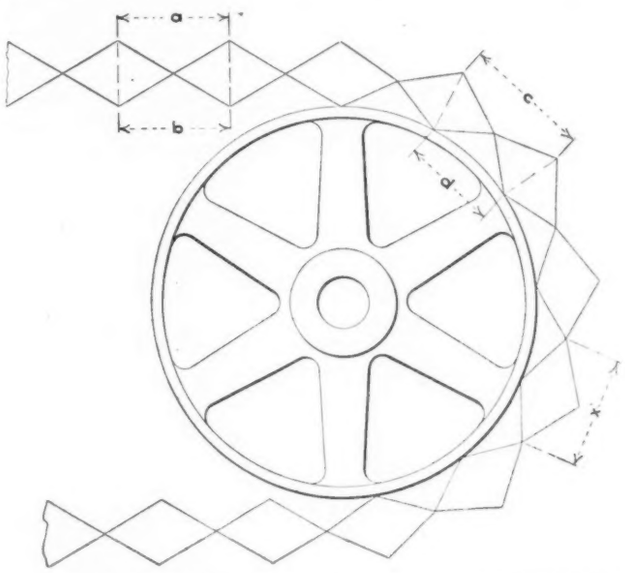
In every rule, with one exception, that the writer has ever seen for finding the speed or size of pulleys, there is the statement, "Allow 1 or 2 per cent. for slippage." There is considerable difference between 1 and 2 per cent. if anything like exact results are desired; besides, nothing is said as to whether it is to be added to or subtracted from the size of the pulley or the revolutions. In other words, the allowing of 1 or 2 per cent. for slippage in figuring pulley speeds or sizes is wrong, as may be demonstrated.

Suppose a pulley 36 in. diameter running 100 r.p.m. belted to a pulley which is to run 1,200 r.p.m. Ignoring for the present the 1 or 2 per cent., it is found that a 3-in. pulley will be required but counting the revolutions of the driven shaft shows that it is making only 1,115 r.p.m. This looks more like 7 than 1 or 2 per cent. Try another case—a 3-in. pulley running 1,200 r.p.m. to a 36-in. pulley on a shaft that is to run at 100 r.p.m. with no allowance for slippage as before; counting the revolutions of the driven shaft, we find that it is actually making 107½ r.p.m. Does this look like slippage?

As a matter of fact, the thickness of the belt must be taken into consideration and added to the diameter in figuring pulley sizes and speeds instead of blindly making

allowance for slippage. In arriving at the result noted in the foregoing examples a belt thickness of ¼ in. was assumed.

Of course a thick belt will transmit more power than a thinner one, or in other words, a thick belt would be less liable to slip than a thinner one. Therefore in the first example, if a belt ½ in. thick be substituted, the driven shaft should run more than 1,115 r.p.m., but as a matter of fact it will be found to run only 1,043 r.p.m.; whereas if the belt had been $\frac{1}{16}$ in. thick, the speed of



ACTION WITHIN BELT IN PASSING OVER PULLEY

the driven shaft would have been 1,177½ r.p.m. These results were obtained by adding the thickness of the belt to the diameter of the pulleys and using this as the diameter of the pulleys.

A number of years ago the writer devised the following formula for determining the size and speed of pulleys:

$$d = \frac{(D+t)R}{r} - t \quad (1) \qquad r = \frac{(D+t)R}{d+t} \quad (2) \qquad D = \frac{(d+t)r}{R} - t \quad (3)$$

$$R = \frac{(d+t)r}{D+t} \quad (4)$$

in which

D = Diameter of driving pulley;
R = R.p.m. of driving shaft;
d = Diameter of driven pulley;
r = R.p.m. of driven shaft;
t = Thickness of belt.

In an actual case the following conditions prevailed: Certain motor-driven machines were designed to run at 100 r.p.m. The pulleys on the machines were 17 in. diameter. The motors were three-phase 60-cycle running 1,750 r.p.m. with 6-in. pulleys. A 40-in. wheel was decided on for the countershaft, and according to the usual rule that is $1{,}750 \times 6 = 10{,}500 \div 40 = 262.5$ r.p.m. for countershaft. Then, to find the size of pulley to place on the countershaft to drive the 17-in. pulley on the machine 100 r.p.m., $17 \times 100 = 1{,}700 \div 262.5 = 6.5$ in. The belt from the motor to the countershaft was ¼ in., and from the countershaft to the machine it was ⅛ in. thick.

Upon starting up it was found that the machines were running 105 r.p.m., and as there were 10 motors, 20 countershafts and 200 machines, it would have been expensive to change pulleys, so the generators were slowed down to about 58 cycles. In this case no particular harm resulted, but if power had been supplied to other industries where exact speed was demanded, it would have been necessary to change certain pulleys.

The explanation or reason the thickness of the belt affects the speed is made clear by the illustration. Assume a belt of pivoted links, as shown. In passing around a pulley the distance a will increase and the distance b will decrease, as indicated at c and d, distance x remaining constant. So it is with a belt; the outside will stretch and the inside will compress, a strata at approximately the middle of the thickness of the belt remaining constant.

The writer once made a model for a local N. A. S. E. which demonstrated this very nicely. An 8-in. and a 2-in. pulley were mounted about 12 in. center to center on a stand. The rims of the pulleys were graduated into tenths and a pointer fixed to the base so that the revolutions could be observed. A number of belts of different thicknesses were provided, and by changing from one belt to another, the effect could be noted.

The Problem of Cooling Water

By A. G. Christie

There are a number of factors that must be considered in designing systems for cooling water for industrial purposes. The more important ones are the average temperature of the water delivered to the system, the average temperature of the air and its relative humidity, the average velocity of the wind, the quantity of water to be delivered, the size of the drops falling through the air and the time of contact between drops of water and the air. It is evident that the greater the temperature difference between air and water and the lower the relative humidity of the air, the greater will be the cooling, other things being constant. Conversely, it will be difficult to cool water on a humid day, when the water is but very little warmer than the air. Wind helps cooling by rapidly removing the warm moisture-laden air from the neighborhood of the cooling system, but on the other hand, it generally carries away a great amount of water spray and may require the erection of barriers and baffles to protect neighboring property owners.

Considering nozzles and a cooling pond, the finer the water is divided in a spray and the longer the time of contact with the surrounding air, the greater will be the amount of cooling—hence the desirability of fine sprays and a long fall for the water. The fineness of the spray and the length of its passage through the air are determined by the pressure at the nozzle. This factor is of importance in determining the height of the nozzle above the surface of the pond, increased height meaning increased pressure on the pumping system. The cost of pumping rises when this pressure is raised. The problem with spray nozzles then is to find the conditions of maximum cooling with minimum pumping costs, and many data need to be collected to enable engineers to competently judge when this condition is fulfilled.

There is an open question as to how much cooling is done by convection to the air or by evaporation of the water increasing the humidity of the air. For instance, it is reasonable to expect that the effect of evaporation will be greater in a dry section like Arizona than in a humid locality on Chesapeake Bay. The amount of makeup water necessary under different conditions is also affected by this consideration. At present there are few independent data available to enable an engineer to judge the relative efficiency of various spray nozzles. In selecting a nozzle then, he should obtain guarantees of its capacity with a given pressure at the nozzle, and of the amount of cooling under certain conditions of temperature difference and humidity.

Locating Ammonia Leaks

By E. W. Miller

SYNOPSIS—The article is intended for those to whom the care of ammonia refrigeration systems is new. The reader is shown how to make sulphur sticks for locating ammonia leaks, how to make Nessler's solution and how to use litmus paper. The precautions to observe when working on ammonia lines are mentioned.

One of the most troublesome problems that confront the refrigerating engineer at times is to account for the loss of the ammonia charge. He knows from the action of the system and by the gage-glass on the receiver that it is gone; but to account for it is difficult.

The greatest single source of loss is leaks. It is safe to say that if every plant in the country was tight we would not hear so much about deterioration of ammonia, and the question of loss of charge would arise but seldom.

Where the condenser is purged frequently, this will occasion considerable loss if it is done in the generally accepted way. As far as deterioration is concerned, if the system is kept reasonably free from oil it is not likely that this will cause an appreciable loss. Where there is a large amount of oil in the system and the compressor is run very hot, it seems that the ammonia decomposes more or less; and this of course will mean a loss. Generally, however, it is the undetected leaks that cause the greatest loss, and every engineer should make it his business to be on the lookout for unsuspected leaks all the time and attend to them as soon as they are discovered.

The biggest job is to locate the leaks; after they are once found, the remedy is usually quite simple. Often it is only a case of drawing up on the bolts in the flanges. For locating the leaks there is nothing better than the old sulphur stick, unless the leak happens to be under water or brine. In this case use litmus paper or Nessler's solution.

Sulphur sticks can be made by anyone, with little trouble and expense, and no refrigerating plant should be without a good supply of them. Sulphur can be had at any drug or chemical store and costs but little. To make the sulphur sticks, place the sulphur in a tin can or pan (a bread pan is just the thing) and place it on anything that will heat it to about 250 deg. F. A hot steam pipe or the boiler breeching is a good place to do this. The bare part at the end of the cylinder of many Corliss engines above the valves is about the best spot I have found. (See Fig. 1.) The top of the steam chest on a pump will serve if the bolt heads do not keep the pan from coming in contact with the hot metal. Melting the sulphur over a fire or a forge is not satisfactory, because the sulphur generally takes fire. If it is desired to melt it in a forge or over a blow-torch, I have found it best to put a plate of iron over the flame and then place the pan with the sulphur in it on top of this plate. In any case it is good practice to cover the pan containing the sulphur, to prevent radiation.

While the sulphur is melting, get some candle-wick and twist it into rope about four strands thick. Cut it up into lengths about a foot long. When the sulphur is melted, dip the candle-wick into it and let it soak for a minute or two and the job is done. Care must be taken not to get the molten sulphur on the hands or fingers, as it hardens instantly and produces painful burns. If candle-wick is not available, get a pine board and make sticks about a foot long and dip these into the sulphur in place of the candle-wick. Either serves very well. If you wish to make considerable smudge, get some sheet asbestos and roll it up into tubes. Put a little fireclay in the bottom to plug the end of the tube, and pour the tube full of sulphur. (See Fig. 2.)

To test for leaks, light one of the sulphur sticks and hold it up to the suspected point, under it if possible.

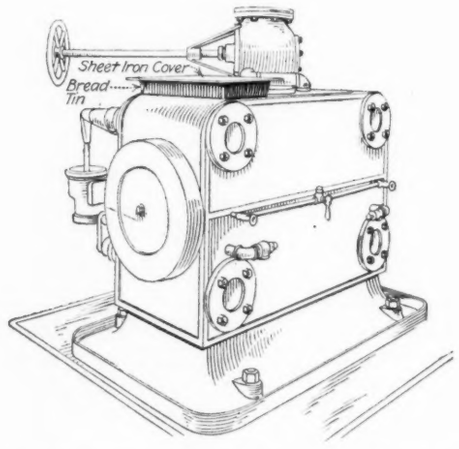


FIG. 1. SULPHUR BEING HEATED IN PAN ON STEAM CYLINDER

The fumes of burning sulphur are practically invisible; but if they get mixed with ammonia fumes, a dense grayish-white smoke is formed. (See Fig. 3.)

Leaks in water or brine are most readily detected with litmus paper or Nessler's solution. Litmus paper can be had from the ammonia manufacturer. To use this paper, simply dip it into the suspected water or brine. If there is ammonia present, the peper will turn blue. Small traces of ammonia will barely color the paper, while any large proportion will turn it a deep blue. Litmus paper, however, will not give reliable indications

in calcium brine. Calcium brine turns litmus paper blue just as ammonia will, and for this reason it is useless for detecting ammonia in this kind of brine. Instead, use Nessler's solution. It is also just as good as litmus paper, if not better, for salt-brine and water tests.

The formula for Nessler's solution is as follows: Dissolve 17 grams of mercuric chloride in about 300 c.c. of distilled water; dissolve 35 grams of potassium iodide

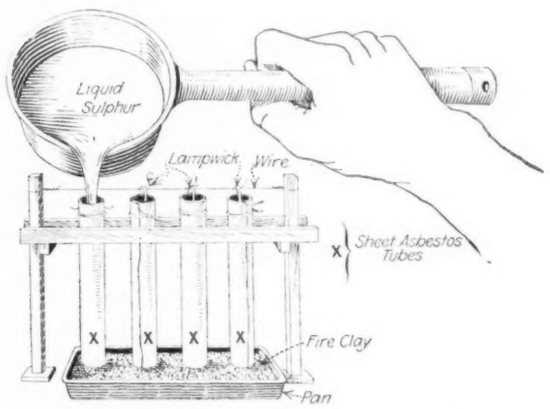


FIG. 2. MAKING THE SULPHUR CANDLES

in 100 c.c. of water. Add the former solution to the latter, with constant stirring, until a slight permanent red precipitate is formed. Next dissolve 120 grams of potassium hydrate in about 200 c.c. of water: allow the solution to cool and then add it to the previous solution and make up with water to one liter. Add mercuric chloride solution until a permanent precipitate again forms. Allow to stand till settled and decant off the clear solution for use. Put it in glass-stoppered blue bottles and set away in a dark place.

In calcium brine, Nessler's solution will always form a precipitate; but if no ammonia is present, the precipitate will be almost white. In water or brine the precipitate will be yellow if there is but a trace of ammonia present, and a reddish brown if there is considerable ammonia in the sample. To make the test, get a sample of the suspected water or brine in any kind of glass vessel and put a few drops of the solution into it. If it changes color, as stated before, the brine or water contains ammonia and preparations should be made to locate the leak.

To get the leaks as soon as they occur, tests should be made systematically at regular intervals. Go over all the open joints with a sulphur stick and test the jacket water, condensing water and brine with litmus paper or Nessler's solution. Most of the leaks will generally be found around the compressor, discharge line and condenser. This is partly due to the high pressure and partly to the temperature changes at different times on this side of the system. A double-pipe condenser especially will need close watching for leaks after it gets old.

If the bolts in the flanges are loose, the leak may be stopped by drawing them up tight. Never try to stop an ammonia leak—on the high-pressure side of the system especially—by drawing the nuts up on the bolts by hammering on the end of the wrench after the nuts are drawn as tight as they will go by hand. If the joints are drawn up as tight as they will go by hand, the safest thing is to pump out and put in a new gasket. I remember incidents where attempts were made to hammer the joint up tight after it was pulled up as far as it would go by hand, and the men came near being killed because the flanges broke. They barely got out before they were suffocated by the escaping gas.

In breaking open joints, even if one is positive that everything is pumped out, it is always best to go slow and be careful. Loosen up the bolts on the flange a little and then gently pry the joint apart. If there should still be pressure on the joint, it is then a simple thing to draw up the bolts again and save the ammonia, and possibly your life. I know personally of two cases where men lost their lives from disregarding this precaution. The men assumed the pressure was all off because the system had just been pumped down. They removed all the bolts in the flanges and hit the joint with a hammer to loosen it. There was considerable spring in the pipe, and the joints sprung wide open. Due to leaky valves, there had accumulated considerable pressure on the line, and the men were caught in a corner where they could not get out.

Now when the joint is opened and the old gasket is out, the next question is what kind of gasket material to use. For the high-pressure side of the compressor, the discharge line and the condenser I prefer the good-grade sheet-asbestos packings. For the liquid line and the low-pressure side of the system, including the expansion coils, I prefer lead. Lead does not give good service on the high-pressure side, because every time the compressor and the discharge line get hot, the joint expands and the lead squeezes together; and when the

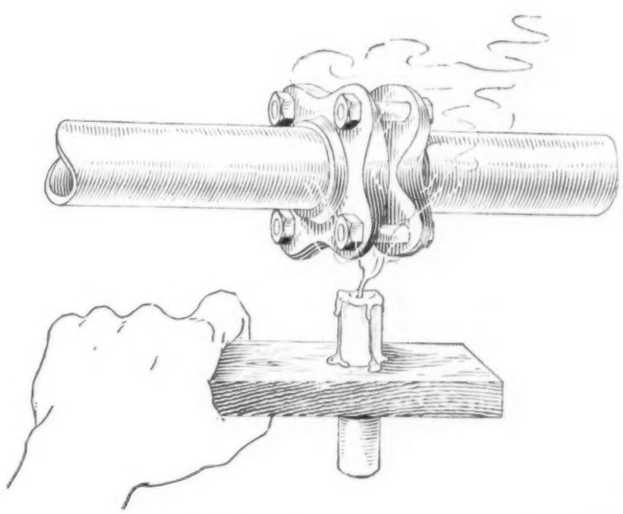


FIG. 3. TESTING FOR LEAKS WITH A SULPHUR CANDLE

line and joints contract, the joint gets loose and starts to leak. There is no elasticity to lead, while the asbestos-sheet packings are elastic. For this reason the high-pressure joints, if they are provided with lead gaskets, need constant tightening if the temperature of the machine varies. Also a lead joint, if it starts to blow, cuts the lead out and it is nearly impossible to stop it afterward by drawing up on the bolts. If an asbestos gasket is covered with a light coating of heavy cylinder oil and then as much graphite as will stick is dusted on and pressed down (not rubbed in) with the tips of the fingers, the joint can be opened any number of times with ease and the gasket will last indefinitely.

For threaded joints the most common practice is to use litharge mixed with glycerin to the consistency of a thick paste. This will not make a tight joint, however, unless the threads are good. Imperfect threads may do at times in a steam or water-pipe joint, but they are sure to start trouble, sooner or later, in an ammonia joint. In using litharge for joints, one should be careful to wipe the joint clean of oil and thoroughly dry with a clean dry rag or waste before applying the litharge; otherwise it will not stick.

Frequently after one is positive that the last ounce of ammonia is pumped out of a coil or line, one will find that there is a considerable odor when a joint is broken. This odor usually comes from ammonia lying in oil in the line or coil, and this ammonia evaporates slowly. In a case of this kind, if one has plenty of time and wishes to prevent the ammonia fumes from escaping, they can be absorbed by wrapping a rag around the joint and running a small stream of water on it. If one is in a hurry, a good idea is to place a common desk fan so that it will blow the fumes away from the man working on the job. Compressed air is still better, because this supplies fresh air to the man who is working.

Water in a couple of pails, with some clean cloths or waste, is a good thing to have around an ammonia plant any time. By saturating a cloth with water and holding it over the nose, one can breathe even if the ammonia fumes are pretty strong. A cloth soaked in vinegar is still better. In case one gets doused with ammonia-soaked oil, liquid or aqua ammonia, the best first aid is another douse of water; if this is done instantly, the burns will be slight.

I had an experience of this kind once. I got ammoniaized-oil all over my face, from a blocked oil line that I was trying to clear. Two of the men grabbed me and ducked me in the water jacket of the compressor for a few moments, let me up long enough to catch my breath and then gave me another ducking. I had only a few blisters to show for my experience; but if I had not received such prompt treatment, the skin on my face most likely would have peeled off.

In making tests for ammonia in brine or water, it is good practice to stop the circulation for a while, if possible, and allow the ammonia to accumulate. In an ice tank, of course, this is not necessary, because here the brine is confined at all times in the tank and the ammonia will gradually accumulate anyway. This is not the case in an open brine system such as is used in the coolers of many packing houses, and with condensing or jacket water. On an atmospheric condenser leaks can often be detected by an accumulation of scale around some of the joints. This is almost a sure sign of a leak either past or present. A test with the sulphur stick, after the water has been shut off the stand long enough for the coil to dry, will soon tell whether or not the joint is still leaking.

Double-pipe condensers sometimes develop pinholes in the pipe, and sometimes the pipes split. The leak may be so small that there may not be enough ammonia in the total amount of water coming from the condenser to affect either litmus paper or Nessler's solution. The best method of testing the water of double-pipe condensers is to shut off a few coils at a time by means of the cocks or valves in the water connections to each coil and let them stand for a while; then draw a sample of water from each coil and test it. Litmus paper does well for this kind of work. If a coil shows signs of leak, drain the coil and take all the return bends off the water pipes and let them dry out thoroughly. Then test in front of each pipe with the sulphur stick. The leaking pipe can readily be found by the dense smoke forming in front of it.

Water Rates of Auxiliaries

By R. von Fabrice

SYNOPSIS—A comparison is made between the cost and water rates of two auxiliary steam turbines, and a problem is worked out showing the capitalization value of one pound of steam per horsepower-hour per year under a given working condition. The same problem is also worked out by the use of a chart.

In power-plant design, whether for a private, industrial or central station, the question of steam consumption of the auxiliaries is too often overlooked or treated with little consideration, while the water rates of the main units are most carefully analyzed. Numerous proposals for generating equipment, together with the necessary auxiliaries, are made by manufacturers, showing great improvements in the water rate on the main units, while that on the auxiliaries is sometimes excessive.

The water rates of the auxiliaries for the main units of a modern generating station hold a very important position in the over-all thermal efficiency of a steam-power station; especially when it is remembered that the auxiliaries of a turbo-generator may consume an amount of steam equal to approximately 20 per cent. of that required by some main units.

Frequently the auxiliary equipment is purchased with only the first cost in mind, the trend of opinion being that auxiliaries are only a side issue to the station, not as already mentioned, a factor consuming possibly 20 per cent. of the fuel fired for the entire operation of the station.

The comparative steam consumption or water rate of any steam-driven unit involves the question of capitalization; or in other words, it is a problem of finance based on a comparison of relative thermal efficiencies.

It is well known that an increase in the economy of the prime movers, as well as the steam-generating equipment of a station, has a relative capitalization value. This value involves the problem of deciding the increased relative value of the purchasing price of a piece of apparatus to be installed over the cost of a less efficient one. Therefore the decision is not based entirely on the first cost, but on the actual thermal-efficiency basis, or capitalization value to the owner.

Capitalization values of various pieces of apparatus offered for a given duty with varying thermal efficiencies

are easily determined if the following facts are kept in mind: (1) Fixed charges, including dividends on the money invested, taxes, insurance, upkeep and depreciation; (2) load factor; (3) thermal efficiency; (4) cost of fuel.

A consideration of the following will illustrate the importance of the thermal-basis purchase of auxiliaries. Let it be assumed that:

1. It is desired to install a steam-driven circulating pump for a condenser.
2. Two propositions have been submitted by different builders, with a relative value of 32 lb. and 33 lb. of steam per brake-horsepower-hour.
3. The pump to require a 350-b.hp. turbine.

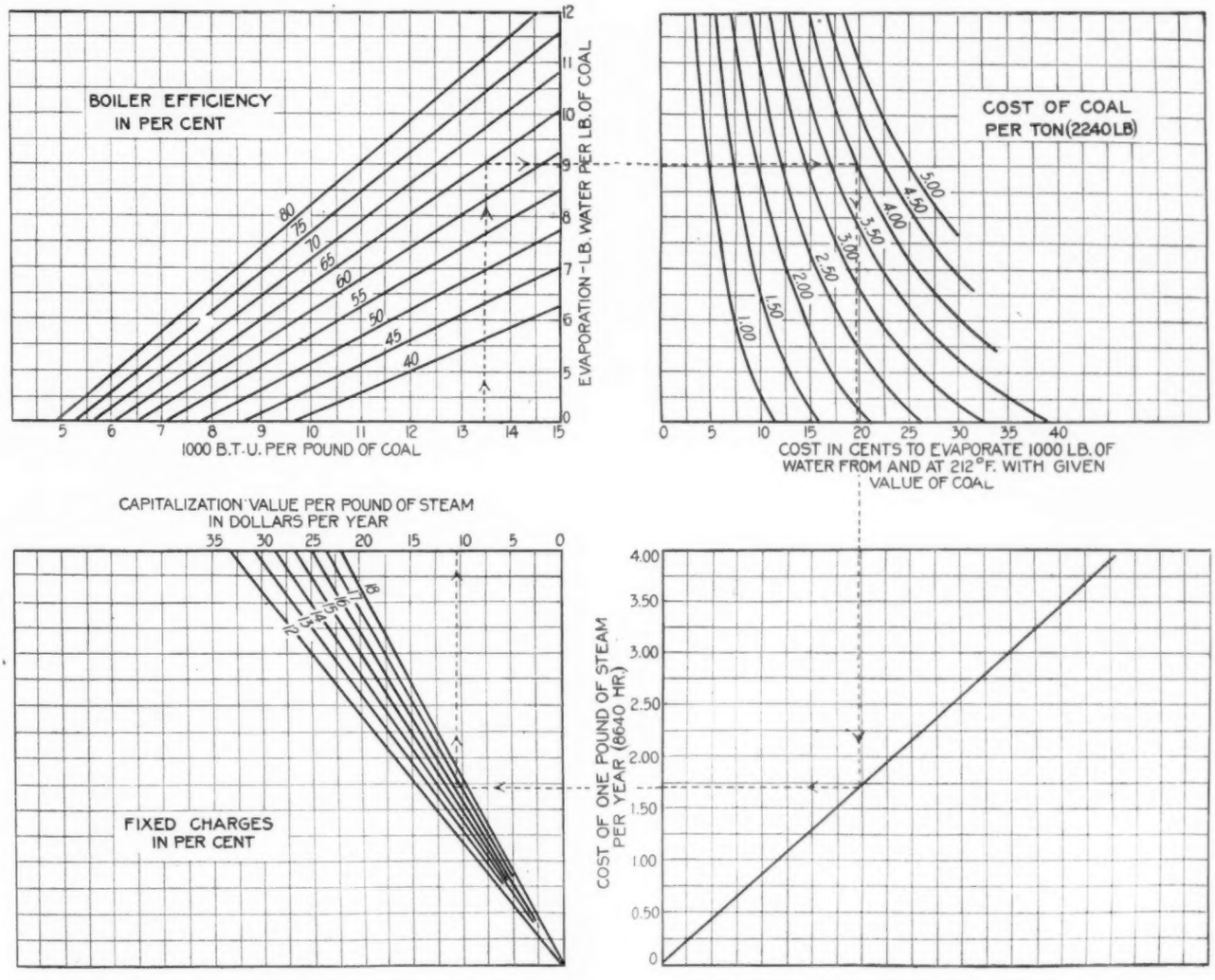


CHART FOR DETERMINING THE CAPITALIZATION VALUE PER POUND OF STEAM IN DOLLARS PER YEAR

4. Difference in cost, $750; that is, the turbine having the 32-lb. water rate to cost $750 more than the other. Cost of pump with 33-lb. water rate, $5,000.
5. Load factor, 100 per cent.
6. Working year, 8,640 hr., or 360 days of 24 hr., which is desired for some large unit installations owing to the fact of the starting and stopping costs for turbo-generators; keep the units in continuous actual service until it becomes necessary to shut down for repairs.
7. Fixed charges, 16 per cent. of the investment.

Further, let us assume that the heat value of the fuel is 13,500 B.t.u. per lb., the boiler efficiency 65 per cent. and the coal costs $4 per ton (2,240 lb.). With coal at 13,500 B.t.u. and boiler efficiency of 65 per cent. the evaporation per pound of coal from and at 212 deg. is obtained by the formula:

$$E = \frac{Hf}{L} = \frac{13{,}500 \times 0.65}{970.4} = 9.04 \text{ lb. water evaporated per pound of coal}$$

where

E = Evaporation per pound of coal;
H = B.t.u. in fuel = 13,500;
f = Boiler efficiency = 65 per cent.;
L = Latent heat, or B.t.u. required to evaporate 1 lb. of water from and at 212 deg. F. = 970.4.

The equivalent evaporation per ton of coal is 2,240 × 9.04 = 20,250. The cost of evaporating 1,000 lb. of water from and at 212 deg. F. is equal to the cost per ton of fuel multiplied by 1,000 divided by the evaporation per ton, or (400 × 1,000) ÷ 20,250 = 19.7c. per 1,000 lb. of water from and at 212 deg. F. The saving of water per hour on the turbine is the turbine brake horsepower multiplied by the difference in water rate per brake horsepower, or 350 × 1 = 350 lb. of steam per hour. For a year of 360 days of 24 hr. (360 × 24 = 8,640 hr. per yr.) the saving is 8,640 × 350 = 3,024,000 lb. steam, making an annual saving at 19.7c. per 1,000

lb. of steam, or 3,024 × 19.7 = $595.73. This saving represents a capitalization value to the purchaser or owner of the turbine of

$$C = \frac{E}{S} = \frac{595.73}{0.16} = \$3{,}723.50$$

where

C = Capitalization value;
S = Fixed charges in per cent. = 16 per cent.;
E = Earning = $595.73.

This shows that the difference of one pound of steam per brake horsepower is equivalent to a capitalization value of $3,723.50, whereas the increase in the cost of the pump is only $750 or approximately 15 per cent. more than the cost of the other pump.

The question of utilizing the steam for heating feed water might at once arise, but in latest developments of power-plant design it is a policy to reduce the quantity of exhaust steam to the minimum, especially where economizers are installed. In installations where economizers are used, it is only necessary to heat the water to 150 deg. F. to prevent the tubes in the economizer from sweating and the consequent sticking of soot to the pipes. In almost every central station of the design mentioned, there is too much exhaust steam available.

Explanation of Computation Chart

To facilitate the computation of similar problems, the accompanying chart has been worked up. Its usefulness may be seen if the foregoing problem is taken into account and followed throughout the four sets of curves as follows:

Beginning with the first quadrant at the upper left-hand corner of the chart and selecting the heat value of the available fuel, which in this case is 13,500 B.t.u., follow up to the diagonal lines representing the over-all boiler efficiency of the station, which in this case is 65 per cent.; then to the right will be given the equivalent evaporation in pounds of water per pound of coal, which in this case is 9.01 lb.; then pass over to the curve in the second quadrant giving the cost of coal per ton (2,240 lb.), in this problem $4; follow the line down to base, which will give the cost of evaporating 1,000 lb. of water from and at 212 deg. F., in this case 19.7c.; then follow the line down to the third quadrant in the lower right-hand corner of the chart, to the intersection of the diagonal line, and turn to the left over to the line giving the cost of one pound of steam per year of 8,640 hr., which in this case is $1.70; from here follow the line over into the fourth quadrant in the lower left-hand corner of the chart, to the diagonal line representing the rate of fixed charges, which in this case is assumed to be 16 per cent.; and from this intersection up to the line showing the capitalization value per pound of steam per year at the assumed rate of fixed charges, which is $10.63 capitalization value for one pound of steam per horsepower per year at the assumed rate of fixed charges of 16 per cent., which is the pound of steam per year capitalization.

Having found the pound of steam per year capitalization value for the existing conditions of boiler efficiency, heating value of fuel, cost of fuel and fixed charges, to find the capitalization value of the steam saving of any comparative unit the formula $C = ceP$ can be used.

C = Capitalization value of economy of the more efficient unit;
c = Capitalization value per pound of steam for determined conditions of boiler efficiency, heat value of fuel, cost of fuel and fixed charges;
e = Economy in steam rate, equals difference in steam consumption between comparative units;
P = Power of comparative machines (it must be remembered that P may be in terms of kilowatt output, brake horsepower, or indicated horsepower, depending upon what even basis the comparison in water rate is taken);

In this problem

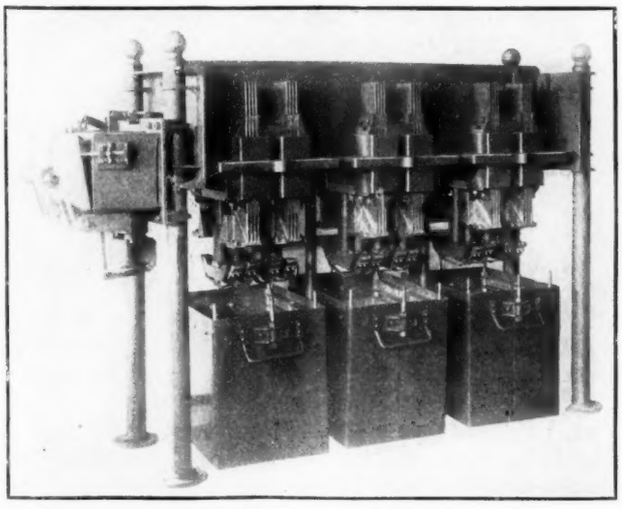
c = $10.638;
e = One pound of steam;
P = 350 b.hp.;

$$C = 10.638 \times 1 \times 350 = \$3{,}723.50$$

From the foregoing can easily be seen the great importance that the relative water rates of the small units (or auxiliary units) hold toward the economical and efficient successful steam-power plant. It should be borne in mind that the facts given hold true equally well either for the new station or for the existing station where alterations are to be made. The process of installing apparatus, main or auxiliary, in any new station or replacing present equipment is only a matter of a financial equation, and it is often the small items such as one pound of steam per horsepower which make an otherwise good engineering feat a failure.

Large Current Capacity Oil Circuit-Breaker

On account of the excessive burning of the current-carrying members and the enormous rise of potential at the instant of opening the carbon-break circuit-breaker on short-circuits, the use of this type of circuit-breaker



5,000-AMP. ALTERNATING-CURRENT OIL CIRCUIT-BREAKER

on alternating-current circuits having highly inductive loads is not to be recommended. There are instances where the opening of the carbon-break circuit-breaker on inductive circuits has produced potential surges high enough to break down the insulation of cables and apparatus.

The characteristics of the alternating-current circuit are such that oil may be effectively used to reduce the arc to a minimum and prevent the burning of the contact members. Owing to the unsatisfactory operation of carbon-break breakers of large current-carrying capacities on alternating-current circuits, there is a demand for an oil circuit-breaker that will handle large currents at a moderate voltage. To meet this demand the Condit Electrical Manufacturing Co., Boston, Mass., developed and placed on the market what is known as its type Y oil circuit-breaker, shown in the illustration. It is built in capacities up to and including 5,000 amp. at 3,300 volts or less.

In the design of this circuit-breaker particular attention has been given to strength of construction, ample current-carrying capacity and insulation. The frame is rigidly constructed and supports the contact members, operating mechanism and oil tanks. The stationary contacts consist of copper bars passing down through the switch frame, but insulated from it. To the lower ends of these bars are fastened the heavy copper contact blocks against which the moving contacts bear. The latter are laminated copper brushes equipped with heavy auxiliary arcing contacts.

The working mechanism is very simple, a single cross-bar operating all brush rods and connected to the operating handle or solenoids through a double toggle and links. The oil tanks are made of heavy iron with electrically welded seams and specially treated wood linings.

Liquid Rheostat Control for Large Wound-Rotor Motors

The extensive use of electric-motor drive for mine haulages, hoists, dredges and similar applications brought to the fore the necessity for a controller for large wound-rotor induction motors which would give wide and accurate speed variation, positive time-limit acceleration and allow the motor to run at reduced speeds for long periods. To meet these conditions the Westinghouse Electric and Manufacturing Co. designed the liquid type of control shown in Fig. 1.

A liquid controller consists essentially of a primary panel, Fig. 2, and a liquid rheostat, Fig. 1. The primary panel is made up of mechanically interlocked magnetic contactors *C* (for starting, stopping and reversing the motor oil circuit-breaker *B*) which entirely disconnect the motor from the line in event of an overload, a fuse knife-switch *S* for the pump motor and a low-voltage relay *R* for the protection of the operator and apparatus against

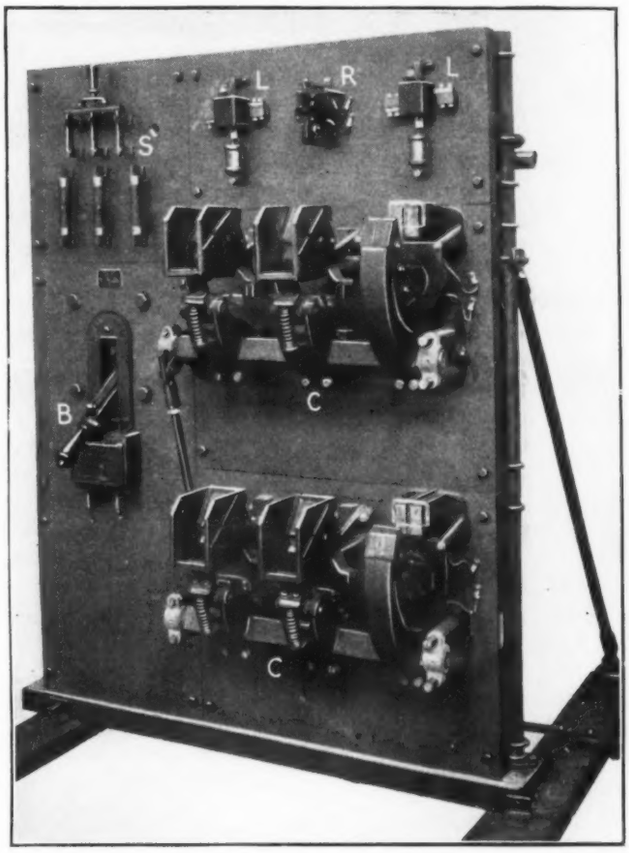


FIG. 2. PRIMARY PANEL FOR LIQUID RHEOSTAT

voltage failure. The secondary control consists of a liquid rheostat complete, for varying the resistance in the motor secondary, a pump and pump motor for the circulation of the electrolyte, and a master switch for the control of the equipment. To prevent excessive heating of the electrolyte, brass or wrought-iron cooling coils are placed in the reservoir. For plugging service a single-lever H-slot device and two overload relays are used. The overload relays *L* are mounted on the primary panel, Fig. 2, and protect the motor from overloads when running, but are short-circuited when plugging the motor. When operating under these conditions the circuit-breaker is set to protect the motor against exceptional overloads and short-circuits on the motor, but too high to trip out in ordinary plugging service. In the type of control shown, the depth of the liquid in which the electrodes are immersed is varied. This principle insures smooth acceleration and close speed regulation of the motor, as an infinite number of steps can be obtained by gradually varying the depth of the liquid. This type of controller is of special value for heavy-duty reversing service, where starting is fre-

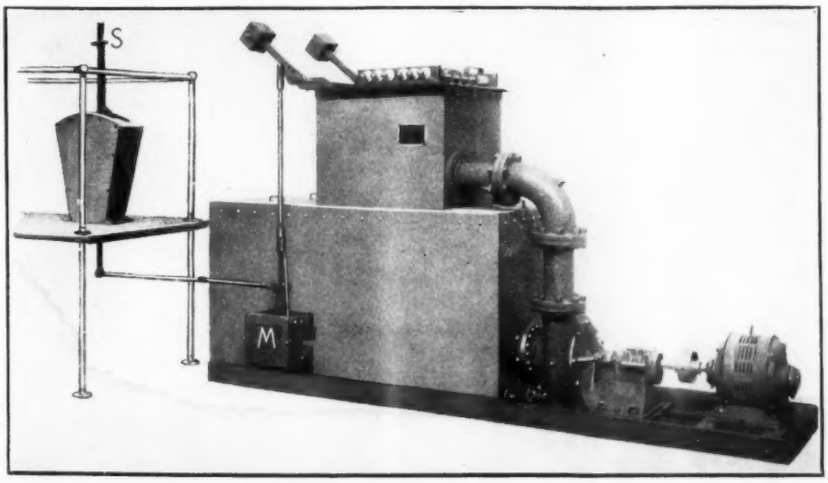


FIG. 1. LIQUID RHEOSTAT COMPLETE WITH CIRCULATING PUMP

quent and the motor is run at reduced speeds. It is built for any primary voltage and frequency and for either two- or three-phase.

The three secondary phases of the motor are each connected to a set of electrodes suspended in the electrode tank. The operating leaver *S* is attached to an arm just above the master switch *M*. When the lever is in the off position, the electrolyte, which is a solution of sodium carbonate (sal soda), is at its lowest level. When the operating lever is moved from the off position, the contactors in the primary circuit are operated by the master switch. The electrolyte, which is circulated continuously by the pump, rises as the weir is raised in the electrode tank. This immerses the electrodes more, decreases the resistance in the rotor circuit and speeds up the motor. By adjusting the position of the weir, the resistance in the rotor circuit is changed and the speed of the motor regulated.

A regulating valve in the pump discharge or intake pipe prevents the liquid from rising in the electrode tank at a rate greater than that for which the valve is adjusted; so the operating lever may be moved directly to the full-on position, while the liquid will rise at the rate determined by the valve setting. The weir, however, is of such a size and design that the electrolyte will flow into the lower compartment fast enough to take care of plugging when that is practiced.

To prevent overtravel in hoist work either single- or double-pole hatchway limit switches can be used. When the hoists are used for lowering an overspeed device is desirable. Cam limit switches form another means of protection, safeguarding against accidents from carelessness on the part of the operator. These consist of a number of switches operated by means of cams mounted on a hexagonal shaft connected to the driving motor or the driven mechanism through a chain and sprocket or through a worm gear.

⁂

Old Packing That Has Been Used should never be put on valve stems or piston rods, because it has lost its elasticity and there is danger of its scoring the rods.

Comparative Movement of Crank and Piston

The accompanying table gives the angles through which the crank has moved and the fraction of the revolution which has been completed for various movements of the piston from the head and crank ends on engines having various ratios of connecting-rod to crank. For example, on an engine having a connecting-rod six times the length of the crank, when the piston has moved 0.05, or $^1/_{20}$, of the stroke from the head end, the crank will stand at 23.97 deg. with the line of centers and 0.066 of the revolution will have been completed; but when the piston has moved the same distance from the crank end dead-center the crank will stand at an angle of 28.20 deg. with the line of centers and 0.078 of the revolution will have been completed. If the engine were running at 120 r.p.m., it would take $(60 \times 0.066) \div 120 = 0.033$ sec. to make the first twentieth of the stroke on the head end and $(60 \times 0.078) \div 120 = 0.039$ sec. to make the same fraction of the stroke commencing from the crank end.

Fraction of Stroke Completed	Connecting-Rod Equals 4 Cranks				4.5 Cranks				5 Cranks				5.5 Cranks				6 Cranks			
	Head End		Crank End		Head End		Crank End		Head End		Crank End		Head End		Crank End		Head End		Crank End	
	Angle Passed through by Crank, Deg.	Fraction of Revolution Completed	Angle Passed through by Crank, Deg.	Fraction of Revolution Completed	Angle Passed through by Crank, Deg.	Fraction of Revolution Completed	Angle Passed through by Crank, Deg.	Fraction of Revolution Completed	Angle Passed through by Crank, Deg.	Fraction of Revolution Completed	Angle Passed through by Crank, Deg.	Fraction of Revolution Completed	Angle Passed through by Crank Deg.	Fraction of Revolution Completed	Angle Passed through by Crank, Deg.	Fraction of Revolution Completed	Angle Passed through by Crank, Deg.	Fraction of Revolution Completed	Angle Passed through by Crank, Deg.	Fraction of Revolution Completed
0.05	23.16	0.064	29.62	0.082	23.42	0.065	29.13	0.081	23.63	0.066	28.73	0.080	23.82	0.066	28.43	0.079	23.97	0.067	28.20	0.078
0.10	33.12	0.092	41.93	0.117	33.55	0.093	41.30	0.115	33.80	0.094	40.78	0.113	34.05	0.095	40.38	0.112	34.27	0.095	40.07	0.111
0.15	41.03	0.114	51.48	0.143	41.99	0.116	50.75	0.141	41.87	0.116	50.15	0.139	42.18	0.117	49.70	0.138	42.43	0.118	49.32	0.137
0.20	47.97	0.133	59.62	0.166	48.50	0.135	58.81	0.163	48.92	0.136	58.18	0.162	49.27	0.137	57.68	0.160	49.58	0.138	57.27	0.159
0.25	54.32	0.151	66.87	0.186	54.88	0.153	66.03	0.183	55.38	0.154	65.40	0.182	55.77	0.155	64.90	0.180	56.10	0.156	64.42	0.179
0.30	60.30	0.168	73.53	0.204	60.93	0.169	72.68	0.202	61.47	0.171	72.02	0.200	61.88	0.172	71.48	0.199	62.25	0.173	71.03	0.197
0.35	66.06	0.184	79.38	0.221	66.75	0.185	78.95	0.219	67.30	0.187	78.28	0.218	67.77	0.188	77.73	0.216	68.15	0.189	77.28	0.215
0.40	71.68	0.199	85.78	0.238	72.42	0.201	84.93	0.236	73.00	0.203	84.25	0.234	73.48	0.204	83.72	0.233	73.90	0.205	83.27	0.231
0.45	77.23	0.215	91.55	0.254	78.02	0.217	90.72	0.252	78.63	0.218	90.07	0.250	79.13	0.220	89.53	0.249	79.57	0.221	89.08	0.247
0.50	82.82	0.230	97.18	0.270	83.62	0.232	96.38	0.268	84.25	0.234	95.75	0.266	84.78	0.236	95.22	0.265	85.22	0.237	94.78	0.263
0.55	88.45	0.246	102.77	0.286	89.28	0.248	101.98	0.283	89.93	0.250	101.37	0.282	90.47	0.251	100.87	0.280	90.92	0.253	100.43	0.279
0.60	94.22	0.262	108.32	0.301	95.07	0.264	107.58	0.299	95.75	0.266	107.00	0.297	96.28	0.268	106.52	0.296	96.73	0.269	106.10	0.295
0.65	100.62	0.280	113.94	0.317	101.05	0.281	113.25	0.315	101.72	0.283	112.70	0.313	102.27	0.284	112.23	0.312	102.72	0.285	111.85	0.311
0.70	106.47	0.296	119.70	0.333	107.32	0.298	119.07	0.331	107.98	0.300	118.53	0.329	108.52	0.301	118.12	0.328	108.97	0.303	117.75	0.327
0.75	113.13	0.314	125.68	0.349	113.97	0.317	125.12	0.348	114.60	0.318	124.62	0.346	115.10	0.320	124.23	0.345	115.58	0.321	123.90	0.344
0.80	120.38	0.334	132.03	0.367	121.20	0.337	131.50	0.365	121.82	0.338	131.08	0.364	122.32	0.340	130.73	0.363	122.73	0.341	130.42	0.362
0.85	128.52	0.357	138.97	0.386	129.25	0.359	138.01	0.383	129.85	0.361	138.13	0.384	130.30	0.362	137.82	0.383	130.68	0.363	137.57	0.382
0.90	138.07	0.384	146.88	0.408	138.70	0.385	146.45	0.407	139.22	0.387	146.20	0.406	139.62	0.388	145.95	0.405	139.93	0.389	145.73	0.405
0.95	150.38	0.418	156.84	0.436	150.87	0.419	156.58	0.435	151.27	0.420	156.37	0.434	151.57	0.421	156.18	0.434	151.80	0.422	156.03	0.433
1.00	180.00	0.500	180.00	0.500	180.00	0.500	180.00	0.500	180.00	0.500	180.00	0.500	180.00	0.500	180.00	0.500	180.00	0.500	180.00	0.500

Crank angles and fractions of revolution completed for each twentieth of the stroke with various ratios of connecting rod to crank.

⁂

Complex Steel is an alloy steel containing more than two alloying elements, such as high-speed tool steel.

⁂

Flow of Steam in Pipes—Commonly used formulas for the flow of steam in pipes are all only transpositions of the equation $H = f \frac{v^2}{2g} \times \frac{4L}{d}$ except in respect to the value of the coefficient (f) of friction of the fluid—whether it is taken as a constant or whether it is a function of the pipe diameter involving the use of still another constant (K) to incorporate the original value of f and also include the variable pipe diameter. Thus, $f = K\left(1 + \frac{3}{10d}\right)$ and reduced to inches $\left(\frac{1}{10} \times 12 = \frac{3.6}{d}\right)$, is $f = K\left(1 + \frac{3.6}{d}\right)$, after which the combined constant is known as K and f disappears entirely and d is diameter in inches. The following values of K experimentally determined, as applied in the formulas, have been given:

Unwin, $K = 0.0027$ to 0.003.
Carpenter, $K = 0.0018$ to 0.00276 (covered pipe).
Carpenter, $K = 0.0098$ to 0.0036 (uncovered pipe).
Arson, $K = 0.005$.
Arson, $K = 0.0028$ (flow of air by experiment at St. Gothard's tunnel).

The average of these values is not far from 0.0027 ordinarily used.

Editorials

Higher Cost of Reading

The fifty-two numbers of *Power* which make up a year's subscription weigh about fifty pounds. At the current rate of a cent a pound, we pay the Government a half-dollar a year to get *Power* to the subscriber.

On December 9 the House Committee on Post Offices voted to include as a rider to the Post Office Bill an amendment, fathered by Representative Randall, of California, applying the zone system, as used for the parcels post, to second-class mail matter. The proposed rates of charge are 1c. per pound up to 300 miles, 2c. up to 600 miles, 3c. up to 1,000 miles, 4c. up to 1,400 miles, 5c. up to 1,800 miles and 6c. above that distance. This would make the cost merely of getting *Power* to the distant subscriber three dollars per year, or a dollar more than the subscription price.

A nation can be no better or greater than its citizenry. In self-preservation and self-development a nation must foster the literacy and intelligence of its people. In a republic compulsory education is held to be necessary that the people may be qualified for self-government. But schooling—the learning to read and write and cipher—does not furnish the requisite knowledge or develop the necessary intelligence. It supplies simply the means, the tools by which one may acquire knowledge and wisdom and keep himself in touch with affairs. Deprive even a college graduate of his newspaper, of his technical magazine, the record of steps in the world's development and the utterances of experts and leaders of thought regarding them contained in current literature, and his value as a citizen would be seriously impaired.

It was in recognition of this fact that the fathers, when the needs of the postal service were much more urgent and the facilities much more limited than now, decreed the flat rate of one cent per pound for periodicals. The result has been a diffusion of printed thought and information that has brought to the dweller in the most remote hamlet the means of entertainment, culture and increased efficiency. There is no doubt that because of this abundant supply of inexpensive reading material the American people are better informed, better qualified to express an opinion upon the questions of the day, better equipped and more efficient each in his own line of endeavor than they would have been without it.

It was a far-sighted, long-headed move. It did what it was expected to do to an unexpected degree, and its usefulness and potency are extending as the organization of industry and society becomes more complex and the need of universal understanding and general discussion of important issues becomes more urgent, as the desirability of the higher efficiency arising from the wider diffusion of technical knowledge increases.

What is the reason for changing it?

The Post Office Department is in no financial straits. It made money last year according to the report of the Postmaster General.

Is there not as much reason for zoning the letter mail?

The cost of the service rendered by the Post Office Department in getting a magazine to its reader is not proportional to the distance which the magazine is transported. The costs of weighing in, getting the magazine transported from post office to train, properly routed and stowed away in its proper car, of transport from car to post office at the end of its journey, distributing, sorting and delivery are the same whether the magazine goes across the county or across the land. The cost of the actual haulage must be small as compared with the aggregate of these other costs. The railroads handle coal for less than half a cent per ton-mile. An additional cent a pound for a 400-mile zone is ten cents a ton-mile for the average distance.

Are the readers of papers and magazines distributed by mail prepared to give them up or to pay double the price for them? That is the main issue.

Shall the current literature of the country home be reduced to a Sears-Roebuck catalog and a Farmer's Almanac, or shall it enjoy the present wide selection?

Are the trades and industries to be deprived of the advantages of their specialized literature and the reported activities of technical, commercial and other societies restricted to those which can stand a haulage tax of ten cents a car-mile?

Your congressman has this matter before him for consideration now. Drop him a note and let him know what you think of it.

This means *you!*

It means that if this amendment goes through, we cannot send *Power* at the present price more than three hundred miles from New York City.

It means the same thing for other publishers and their publications.

It means a higher cost for all your periodical reading matter except your local paper.

And it offers you no compensating advantage.

Send that note to Washington now!

A National Committee on Power-Plant Efficiency

Some weeks since *Power* ventured the thought that the time may come when Governmental supervision of power plants might concern itself with their efficiency as well as their safety. There is a growing appreciation of the fact that the effects of waste extend to others than the waster. It has long been recognized that the loss occasioned by a fire is not confined to the man whose property is burned or to the company that insures it. The more fires the higher are insurance rates, so that all who are insured contribute directly to the loss. But since insurance is a legitimate item of cost in the various business of all those insured, everybody who buys or uses their products must pay a little more in order that they may make the same profit. Then there is the effect of the destruction of the fruits of labor upon the available

supply, and in one way and another many people will contribute to their restoration. At the American Uniform Boiler Code Congress recently held at Washington, Dr. F. R. Hutton demonstrated in a masterly way that a boiler explosion is not a personal but a communal catastrophe. Loss, especially recurrent or continuous loss, parcels itself out automatically over a wide circle. Is not this just as true of losses which are not accompanied by violent demonstrations like conflagrations and explosions? The concentration of the loss into a few minutes startles and compels attention, but is the loss any less real if it is the result of continuous waste and inefficiency? And is it not true that in any system in which price is determined by cost plus a fair profit the loss falls upon the ultimate consumer?

If this is true, is it not a legitimate function of the government, in the conservation of its resources, in the fostering of the common weal, to restrict waste and to develop and insist upon efficiency; and cannot a people through its representatives, undertake this in its own behalf in times of peace as well as of war?

At the Uniform Boiler Code Congress Prof. L. P. Breckenridge said that if an inhabitant of Mars or some other extraterrestrial body was able to scan the peoples and processes of this earth, he would be puzzled by the apparent fact that one group of terrestrials was working to dig coal out of the bowels of the earth while another group was making frantic efforts to burn it up as fast as possible under steam boilers.

At the recent meeting of the American Society of Mechanical Engineers Victor J. Azbe presented a paper which had received honorable mention in the Junior Prize Contest of this year. The title of this paper was "Power Plant Efficiency," and it dealt, not with tests or thermal efficiencies, but with the efficiencies at which power plants, especially moderate-sized power plants, are run and the improvements that are possible in their operation. Rising superior to the resentment of the plant manager at interference with his methods and his fears that they would lead to the organization upon a sordid basis of a class of men who have always identified themselves with the executive side of the business, he boldly says:

> License laws and examinations would conduce to the better education of operating engineers, but in 60 per cent. of the United States, by population, there is no license law, and the other 40 per cent. consider only ability to operate a plant safely—seldom economic operating ability. It is declared unconstitutional to examine for efficiency. Since the welfare of our descendants and the ability of the American nation to be a world power and commercial leader depend upon an ample coal supply, if laws for its conservation do not exist they should be made.
>
> License laws should be more stringent, examinations more complete, licenses graded and issued for intended plants. Since fuel-loss prevention is a national problem, efforts should be made to obtain a Government standard license law all over the United States, and members of examining boards should be civil-service employees of the United States Government, thus eliminating politics.

And not a voice was raised in derision or protest—on the contrary the author's suggestion that the American Society of Mechanical Engineers start the movement by forming a committee for the prevention of fuel losses and for the general betterment of power-plant conditions was referred to the council by a unanimous vote.

The author's ideas with regard to the plan and scope of such a committee were later expressed as follows:

> The agitation should be country-wide, but the committee should be only the head of the movement; it will agitate for and operate on the order of a general staff. There are many periodicals, organizations and schools working in the direction of power-plant improvement and education for greater efficiency, but their actions are too individual with no coöperation. To bring these educational factors more closely together, so that they will work in concertissimo with one goal in front of them all, will be the primary action of the committee. In the agitation for better power-plant conditions there will be large and small battles to be fought, but the real action in all of them will be taken by the smaller educational factors under pressure and direction of the American Society of Mechanical Engineers.
>
> We should also join the German and English committees of this kind with the American committee, thus causing a concerted action which will be of great value to us. We should also get all the German and English reports, study them carefully and adopt anything to our value. Of course it is necessary that anything idealistic and impossible under conditions should be eliminated and only things started that can be finished. We cannot copy the Germans and English all through, since our country is not ripe for this.
>
> We must get the help of all engineering magazines.
>
> The National Association of Stationary Engineers and all other such societies should be made to coöperate.
>
> Newspapers should mold the public opinion.
>
> Universities should give courses for which they should ask only a very small fee
>
> Gather information pertaining to power-plant conditions and improvement and publish it in the annual report of the committee.
>
> Get examining boards, boiler-inspection and smoke departments, business men's leagues and chambers of commerce interested and engage their help.
>
> Agitate for a general license law.
>
> Interest the Government and cause it to first exert slight pressure and later increase it when conditions become ripe to do so.
>
> Make effort to form steam users' societies, consisting of plant managers and owners.
>
> Issue reports on apparatus of not known value but economic possibilities, also reports and suggestions on methods of management and operation.

The possibilities before such a committee would be enormous. We congratulate Mr. Azbe upon having brought out these possibilities so convincingly and trust that the council will lose no time in getting those possibilities in line for realization.

Determining Power Costs

Among progressive operating engineers there is no subject in which keener interest is taken than that of power costs, which, of course, includes heating and refrigeration. To know how the other engineer gets at his power costs is always desirable, but the desire to know is more often disappointed than fulfilled. The chief engineer of a large department store stated not long ago that a representative of his company, in visiting many of the largest stores in the country, was unable to obtain anything of value to guide and assist the engineers in apportioning costs and improving their system of cost and record keeping, and that most stores kept practically no record at all of their power costs.

In this issue C. A. Whiting, a consulting engineer at Boston, who is also a certified accountant and engineer for the Massachusetts Board of Gas and Electricity, which determines rates, etc., offers some suggestions on cost keeping that many of our readers will find applicable to their needs.

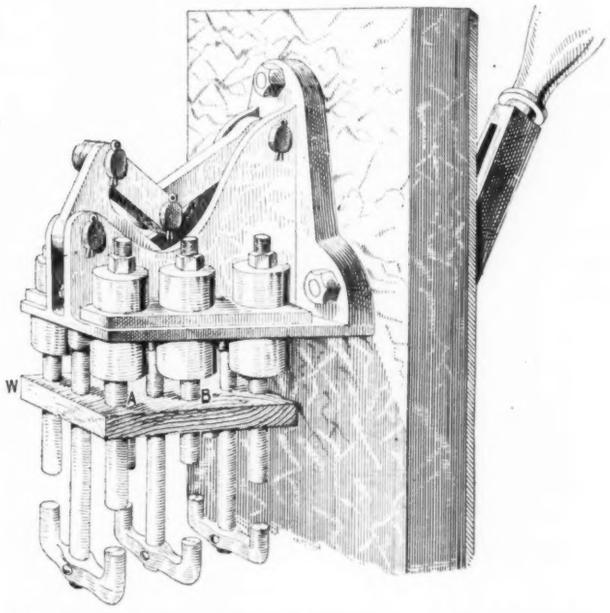
The following observation by a correspondent of London *Engineering*, in regard to a meeting of a technical society, is of widespread application: "The outstanding feature of the discussion was the unanimous silence of all gentlemen present who had any special knowledge of the subject."

Correspondence

Water Leaked Through Cable Into Oil Switch

The following experience may be of interest to readers of *Power*. At a substation used to step up the voltage from 2,200 to 22,000, a 300-amp. three-pole 2,200-volt single-throw oil circuit-breaker tripped out, and when the attendant threw it back in, he noticed smoke coming from the oil tank.

The switch acted all right for a few days and then tripped out again. The operator thought there was something wrong on the inside of the oil tank; but nothing could be done at that time, as the circuit had to be kept



OIL SWITCH SHOWING LOCATION OF WOODEN PLATE AND SHORT-CIRCUIT

alive if possible. On the following Sunday the oil reservoir was lowered and the wooden plate, shown at *W* in the figure, through which the upper contacts protruded and which was immersed in oil, was found to be very badly charred. The contacts and wooden plate were cleaned, the charred wood was all scraped off the plate, and an examination made to see what had caused the short-circuit. There was nothing visible that would cause a short-circuit, so the oil was strained to take out the charred wood, etc., and the reservoir was replaced and the switch put back into service. It acted all right for a few days and then tripped out again, considerable smoke coming from the oil tank and the oil appearing very warm.

The switch was again inspected, and while doing so the lugs which the stranded cable were soldered into were disconnected and turned back out of the way. After a few minutes' inspection of the switch, a small wet spot was noticed on the concrete floor under one of the cable lugs. Upon further investigation it was found that the water was coming out from between the strands of the cable. The cable was 250,000 circ.mil. cross-section and was insulated with varnished cambric and an outside covering of braided asbestos. It was tapped to a feeder outside the substation at the crossarm and dropped down a distance of six feet, and then through a porcelain tube embedded in the wall to the inside of substation, then down through a conduit to the floor and under the floor through a conduit a distance of 15 ft. to the switchboard. There it turned and came up three feet and the cables then bent over and down, forming a sort of gooseneck above the switch.

At the point where the wires were tapped to the feeder at the pole, the joint was not made water-tight, consequently, the water during rains worked its way in between the cable strands. The outside insulation would not let the water escape from between the strands until it had worked down and over to the switch, where it ran down the lugs, dropping on the inside wooden plate and lying there until enough had accumulated to bridge the distance between terminals, forming a short-circuit as between *A* and *B* in the figure. What made it difficult to locate the cause of this trouble was the fact that it was so long between drops that in making a hurried inspection the water was not noticed. Making the outside joints water-tight by a careful tapping and painting with shellac cured the trouble.

C. J. BRINDLEY.

Mansfield, Ohio.

Centrifugal Boiler-Feed Pumps

I read with considerable interest and surprise the article on boiler-feed pumps in the issue of Oct. 31, page 609, since it apparently purports to describe the best design, but there are a number of features in connection with it that are open to question and are at variance with my experience extending over a period of many years.

A centrifugal boiler-feed pump should be designed with a head-volume characteristic in which the maximum pressure at full speed is not more than 20 per cent. above the normal working pressure at rated capacity. If the pump is driven by a constant-speed electric motor, the pressure at reduced capacity will not become excessive for feed lines, economizers, etc.; and if the pump is driven by means of a steam turbine fitted with a pressure-regulating governor, which should be of the constant-pressure type, the percentage of speed reduction for reduced capacity will be small, maintaining good economy for the turbine.

The statement in regard to the comparative efficiency of turbine- and motor-driven boiler-feed pumps might be misleading, because there are many plants where the exhaust steam is valuable for heating purposes, which makes the turbine-driven machine preferable for those particular plants. A single-stage pump can, of course, be used for feeding boilers if the speed is high enough, but high velocities cause rapid wear and the large difference in pressures between the suction and discharge chambers requires a very effective type of packing rings at this

point, and these rings are subject to rapid wear—all of which makes the upkeep on single-stage pumps high.

The article places considerable stress on the use of diffusion vanes, but I believe it is widely admitted that these rings are more harmful than beneficial when all details are considered. Some of the weaknesses of these vanes are pointed out in the articles, such as the leakage between the diffusion-vane casting and the pump casing, which loosens the diffusion-vane ring and necessitates extensive repairs.

Furthermore, boiler-feed pumps are usually ordered for a greater capacity than actually required, and in most cases they operate under variable capacities and often under variable pressures. Since diffusion vanes can be made with the correct angle for one condition of capacity and head only and pumps without diffusion vanes can be made with flatter efficiency curves than those with diffusion vanes, the over-all efficiency of a pump with diffusion vanes, when operating under the variable conditions in service, will not be so good as that of one without such vanes. Pumps without diffusion vanes can be built for as high pressures per stage as those with diffusion vanes, and the former, under certified tests, have shown as high efficiencies for the same conditions as the latter. I know of one installation of a pump with a capacity of approximately 5,000 gal. per min. at 275 ft. head per stage showing an efficiency of almost 79 per cent. under actual test, which is certainly an excellent performance for a centrifugal pump of any design.

Regarding making tests, there are in most cases sufficient facilities at the installation to enable the customer to get quite a close check on the actual performance of the pump, and the manufacturer would certainly be taking great chances to depend on a lack of testing facilities to allow him to make unreliable guarantees.

The usual construction in this country now is to screw the wearing ring on the impeller instead of forcing or shrinking it on and it is to be preferred because a much better job can be done in this way. The design of wearing rings submitted would not appeal at all to me, and the fact that operators are liable to run the pump empty would seem to condemn this type of ring, for the ring would then rest on the impeller and would certainly be cut and damaged sufficiently to impair its usefulness. Furthermore, the lodging of small solid particles between this ring and its seat cannot be avoided, and these would cause leakage and the small clearance (0.004 in.) would no doubt lead to rubbing.

Labyrinth wearing rings, properly designed and made, will not rub or freeze whether operating with or without water in the pump. I have run many pumps without water, but of course was sure of the construction, and I have never had any such trouble with these rings. Experienced designers allow for the expansion of the metals due to the temperature of the water.

The statement that 600 gal. can be handled by a single-suction pump running at 3,000 r.p.m., but that for high speeds and capacities over 600 gal. a double suction is recommended, is misleading to the average person because it does not take into consideration the head against which the pump must operate. It is my opinion that feed pumps should not be built for a higher speed than 3,000 r.p.m.; for higher speed usually requires considerable repair, while slower-speed pumps have been operated for three years without repairs of any kind.

Any centrifugal pump, either double or single suction, may be unbalanced for end thrust. In double-suction pumps operating conditions or the inequalities of castings will occasionally cause the pump to be unbalanced, and it is far more difficult to correct unbalancing in a double- than in a single-suction pump, for as a rule the double-suction design does not provide for correcting possible unbalancing. I know of several double-suction multi-stage pumps being so badly unbalanced for end thrust as to make it impossible to operate them, and they had to be replaced with single-suction machines; therefore I am convinced that the claim for natural hydraulic balance on a double-suction multi-stage pump is not substantiated in enough instances to be considered an advantage for this type of pump at all. Single-suction pumps are sometimes hydraulically unbalanced when installed, but this can be overcome without much difficulty.

The double-suction multi-stage pump has disadvantages such as the extra-heavy shaft, long span between bearings, greater space occupied, higher first cost and more complicated castings.

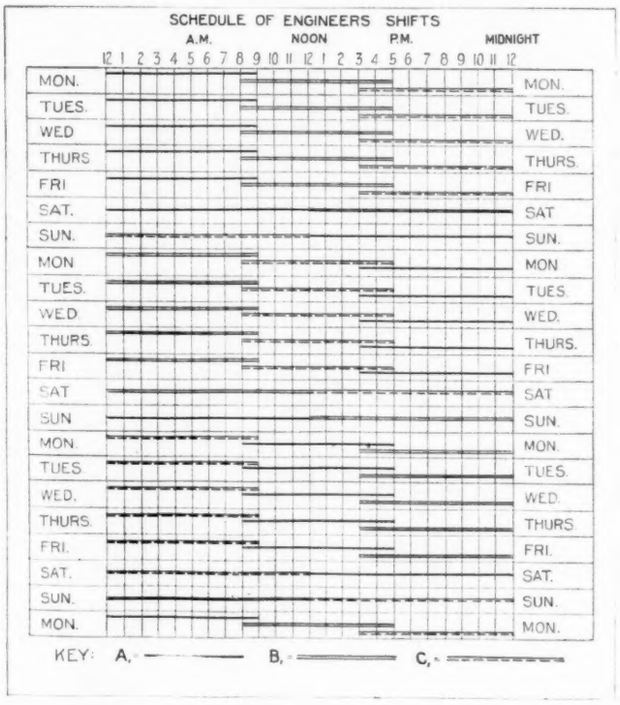
There are other statements of minor importance in the article, but probably not deserving of special mention in a criticism.

H. A. Schultz.

Pittsburgh, Penn.

Watch Engineers' Time Schedule

Some readers may be interested in the graphic schedule of shifts for three engineers in our engine room, covering 24 hr. a day, 7 days a week. It is so arranged that the



OVERLAPPING TIME OF WATCH ENGINEERS

men (designated as A, B and C) work 9 hr. a day except Saturdays and Sundays, when two work 12 hr. so as to give one man one day off a week. The problem was to shift the watches, or have the men work at different times different weeks and not have any man work more than 12 hr. on any one day. In making the shift one man

works 69 hr. one week, and the other two work 57 hr. that week. They each average 61 hr. per week in three weeks. Notice that they lap one hour in the morning and two hours in the afternoon. This is for the purpose of giving the new man coming on duty an opportunity to become acquainted with the happenings of the previous watch, so that he may take up his duties with intelligence. We consider it a mistake to have one man quit and another one take his place without having an opportunity to learn of the happenings of the day.

Brooklyn, N. Y. WILLIAM N. SCAMMON.

Draft and Its Application

I have read with interest the article, "Draft and Its Application to the Steam Boiler," by E. A. Uehling, in the issue of Nov. 21, and do not accept fully all the statements therein made. I refer specifically to page 713, where the individual blower system is discussed. Mr. Uehling, after briefly stating some of the advantages of the individual fan blower system, mentions what he considers the disadvantages and first refers to its higher steam consumption.

At certain points of operation it is true that the individual blower may be inherently less economical than the large central centrifugal blower. For instance, an individual blower delivering, say, 5,000 cu.ft. of air against a static pressure of 2 in. of water might in itself be slightly less economical proportionately than a centrifugal blower delivering, say, 50,000 cu.ft. per min. against the same pressure. That is, the latter would perhaps take less than ten times the horsepower required to drive the individual blower. This, however, is only one of the factors to be considered in comparing the economy of the central fan system with that of individual blowers. One point frequently overlooked is that when a central fan is connected to a number of boilers, it is necessary for it to deliver all the air at a maximum pressure; that is, the highest pressure required by any one boiler at any time plus the pressure required to overcome the loss in the system of ducts. The result is that the fan must always deliver the full volume of air against this maximum pressure, even when only a small part of the air is being used against that pressure, the rest being throttled down to various lower pressures as required by the condition of the fire in the individual boilers.

Against this must be contrasted a system of individual blowers where each one is delivering the air only against the pressure required by the furnace conditions for that boiler with no waste of power delivering air against a higher head than actually needed, which in the case of hard coal might be, say, ¾ in. for a fire just cleaned, 1 in. in the next latest cleaned, 1½ in. for the third and 2 in. for the fourth soon to be cleaned. With a central fan connected to four such boilers, all the air must be delivered against a pressure of from 2¼ to 2½ in. of water. Thus the slight inherent advantage in economy of the large fan is probably all lost.

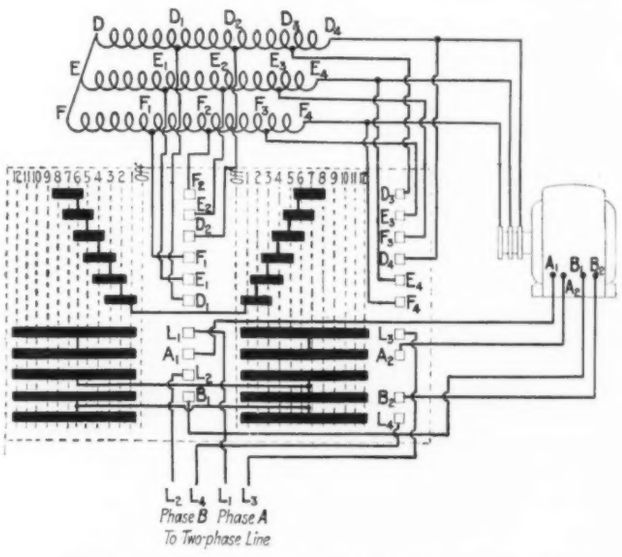
Another objection cited in the use of the individual blower—that this machine is "apt to speed up with increasing steam pressure unless automatically regulated, which is contrary to the requirements"—does not apply if the blowers are automatically controlled by the steam pressure. The same regulation may be obtained in either type, and there is no reason why this should be claimed as a disadvantage of the blower rather than of the central fan system, for in either without a satisfactory automatic regulation there will be a similar variation in speed.

I therefore hold that these two conclusions in particular are inaccurate in that the general statement that a central fan system is more economical than a system of individual blowers is not essentially true, as a comparison must be made separately for each individual installation. In a majority of cases it will be found that there is very little difference in the total efficiency of the two systems. Furthermore, so far as the regulation is concerned, Mr. Uehling has apparently overlooked the fact that regulators are to be had which operate within such narrow limits that the objection does not hold.

New York City. V. H. CARPLES.

Induction Motor Hunted

Ordinarily the word hunting is used for expressing the unstable action of an over-sensitive engine governor, an electrical regulator or of some electrical machine—such as a synchronous motor, for example—the unstable action of which may be due to periodic fluctuating of the speed of the prime mover on which the motor depends for driving power. The idea of hunting is associated with that of rhythmic-speed variation or of rhythmic-energy variation; therefore, it would not seem to be much out of place to refer to unexplainable rhythmic-speed variations of devices not ordinarily addicted to hunting in the true sense in which the term is generally accepted. As an instance to illustrate this application of the word, the following may be interesting:



REVERSING CONTROLLER DIAGRAM FOR WOUND-ROTOR INDUCTION MOTOR

A paper-mill electrician who had had some experience with the hunting of synchronous converters complained that a large three-phase induction motor that was driving a main shaft to which was belted several heavy-duty paper machines had developed a tendency to hunt when the controller was on the last position. The periodic-energy variation could be plainly seen on the needle of the ammeter connected in the primary circuit of the motor.

Unless there are special reasons for avoiding it, the connections of induction-motor controllers generally are

such that a section of the rotor resistor is cut out of first one rotor phase and then out of another, every third notch being a so-called *balanced* notch and all other notches being unbalanced notches as shown in the figure. Whatsoever may be the sequence of cutting out the rotor-resistor sections, however, the last notch always is a balanced notch, because on that notch all of the resistor is, or should be, cut out.

It was ascertained that the peculiar action of the motor dated from the time that a defective fire-sprinkler plug had deluged the outfit with water. The motor had been working all right ever since excepting for the tendency to hunt. As everything appeared to be well protected excepting the resistor, it was carefully examined and a broken grid discovered between E_3 and E_4; presumably the grid had been broken by the water striking it when hot. The unit was disconnected, removed and repaired. In connecting up, it was discovered that, as originally connected, E_3 and E_4 had been interchanged, which accounts for the magneto indicating a closed circuit when the broken grid should have caused it to indicate an open one. When the controller was advanced to the last notch, the resistance section between E_3 and E_4 was cut in instead of out, thus opening one phase of the rotor. This threw it out of balance electrically and caused hunting. After the resistor had been repaired, operation again became normal. E. C. PARHAM.

Brooklyn, N. Y.

Wanted: Covering for Vertical-Boiler Heads

Allow me to inquire through *Power* what experience and success readers have had with covering for the heads of vertical boilers. These boilers are cleaned and the tubes are renewed from the top, so there is a good deal of tramping about on the boiler head. I would like to hear, from those who have had satisfactory experience with covering for heads, the name of the material and how long it lasts.

Ontario, Canada. H. T. WESTWOOD.

Repairing a Leaking Float

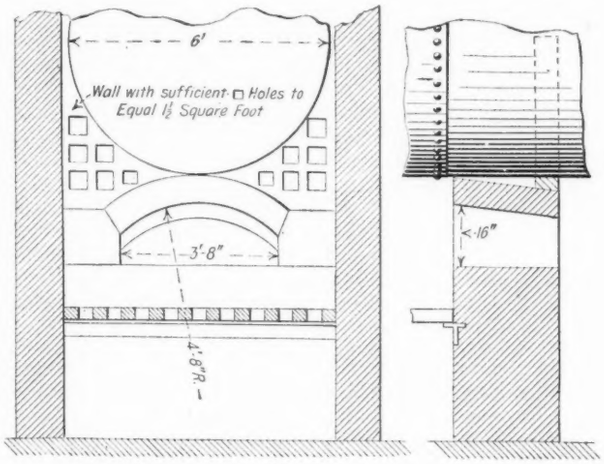
A simpler method of repairing a leaking float than the bolt arrangement described on page 632 in the issue of Oct. 31, if the float is to be used in water that is not too hot, is the expedient once suggested by me for a float about 8 in. diameter controlling the shutoff valve on a small standpipe supply line. The engineer tried to solder it, but the expansion of the air inside when heated prevented making a perfect seal. I happened to be looking on, and having a heavy rubber band in my pocket, I suggested that it be put around the ball over the hole, and it appeared to hold perfectly. To make sure, however, rubber cement was applied while the ball was heated to about 140 deg. and the air within permitted to escape.

When the float was replaced later, it was found to be dry. I then tried my hand at soldering, taking a leaf from the engineer's book of experience in so doing. The float was partly immersed in hot water to expel as much of the air as possible from within and was soldered while still hot, but at the instant of applying the solder it was cooled with cold water and the solder "took" and held perfectly. CHARLES C. LYNDE.

Pittsburgh, Penn.

Improved Furnace Construction

I have followed with interest the discussions on the bagging of boilers and suggest a remedy for Mr. Wright's trouble (see issue of Aug. 1, page 173). From my experience I have decided that the method and location of water entering boilers has very little effect on the deposit of sediment in any particular place, but that this is due to the violent local circulation, or eddy, which it is impossible to avoid in the ordinary setting, and which causes the sediment to be deposited on the outer



SPECIAL FURNACE CONSTRUCTION

edges of this eddy. On account of the circulation being greatest over and just in front of the bridge-wall, there is a possibility of the sediment being deposited about the center over the firebox.

The illustration shows the method I use to prevent this and such ailments as leaky girth seams, bagging and foaming. This method also causes a remarkable improvement in the combustion. It will be noticed that the arch deflects the gases from the boiler and toward the bottom of the combustion chamber. The curtain walls above the arch are slightly checkered so as to permit part of the gases to pass over the arch to utilize all the heating surface. On account of the larger percentage of gases passing under the arch and through the restricted space over the bridge-wall, combustion is not only improved, but there is a uniform distribution of heat over the entire heating surface and this transforms the section of localized heat to normal temperature even when boilers are forced beyond their rated capacity. This arch is easily constructed, the initial cost is small, and if installed with reasonable care, it will require no more attention under ordinary circumstances than the walls of the furnace.

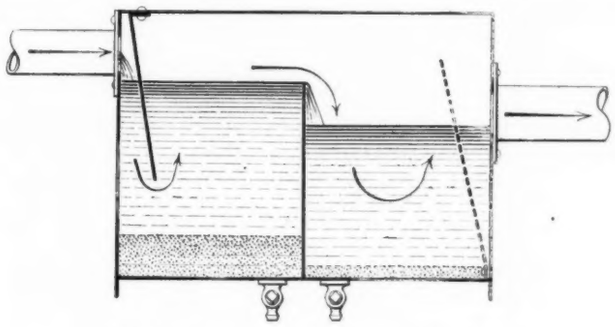
I have used this construction for years and find, when the boilers are opened for cleaning, that nearly all the sediment is piled against the front manhole cover.

Kansas City, Mo. WILLIAM J. MANHIRE.

Killed by Carbon Monoxide—An instructive case of doing things the way they ought not to be done was that of a boiler maker and his helper at Goulburn, N. S. W. According to a report in the "Australian Mining Standard," they entered the water tank of a locomotive tender through the manhole, and as the weather was cold, they took a drum of live coals with them. Some hours later both were found lying dead at the bottom of the tank, having been killed by carbon monoxide.

A Trap for Filter Sand

All the water used for industrial purposes in our plant passed through ordinary sand filters, and considerable difficulty was experienced at times, especially after the filters had been cleaned by agitating the sand, as a



SAND TRAP IN WATER-SUPPLY LINE

great deal of sand was carried over in the water, lodging in the piping and cutting the valve seats, pump chambers, etc. To overcome this trouble we placed an old tank with a vertical baffle in the center of the pipe line from the sand filters, forming a collecting trap into which the sand would settle because of its weight and the decreased velocity of the water in the tank. A perforated baffle was also placed over the outlet opening to prevent as far as possible eddy currents in the outboard side, which also served as a settling place. Two blow-offs, one for each chamber, were provided at the bottom of the tank for getting rid of the sand

Philadelphia, Penn. M. A. SALLER.

Vibration in Steam Turbines

In the issue of Oct. 3, page 489, steam-turbine vibration was discussed in some of its forms, but the discussion seemed to relate to reaction rather than impulse turbines and some of the most frequent troubles of the latter were omitted.

Improper fitting of the carbon or metallic packing rings is one of the most common causes of vibration in impulse turbines. Rings that are smaller in diameter than the shaft tend to pinch when under pressure and set up vibration until the ring has worn clear. If the packing becomes jammed in the holders, so that it is forced against the shaft, noise and shaking will result.

Bearings improperly assembled so that the shaft is pinched or the ball joint bound, preventing self-alignment, will also cause vibration. There is considerable latitude in the matter of bearing clearance. If the set is not in perfect alignment or balance, small clearance is advisable, while if the adjustment is first-class, a large bearing clearance does not usually make trouble. I have seen a 3,000 kw. unit with a journal about 10 in. long with a total clearance of 0.16 in. (nearly $\frac{3}{16}$).

Misalignment of the bearings is sometimes met with, due to misplaced shims, settling of foundation, weight or expansion of improperly designed piping, etc. This vibration is characterized by its absence at no load, but appearing as load is applied. Sympathetic vibration of foundations resulting from the steel or reinforced structure receiving and magnifying any small vibration set up in the turbine is often troublesome. Violent vibration is sometimes caused by the generator, when a joint in the electrical circuit of the rotor becomes loose. Shaking spells are sometimes caused by water coming over in the steam.

From what I have observed in all types of turbines, while the causes of vibration are perhaps not exactly mysterious, diagnosing the trouble is not always so simple and easy as one would imagine. However, with the methods at the factories so developed and perfected as at the present time, but little adjusting is necessary at the plant, so that the engineer is not often called upon to exercise his ingenuity. EUSTIS H. THOMPSON.

Baltimore, Md.

Lock Washer for Capscrews

Supplementing Mr. Bentley's method, described in the issue of Oct. 24, page 597, of securing the valve-plate capscrews on a Westinghouse air pump, the lock washer shown in the illustration does not require so much time and labor and is equally sure. Fig. 1 shows a washer of sheet iron about $\frac{1}{32}$ in. thick, which is to be laid on top

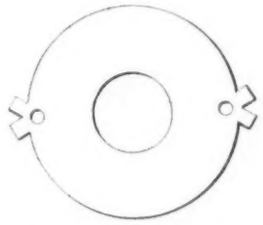


FIG. 1. WASHER CUT OUT

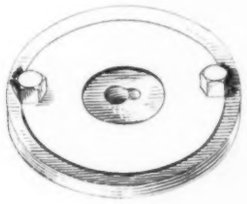


FIG. 2. IN PLACE UNDER BOLTS

of the valve plate and the bolts inserted through the holes and tightened. The "ears" on each side are then bent up against the head of the bolts, as shown in Fig. 2. Experience has proved the usefulness of this easily made washer. F. DRYNAN.

Kansas City, Mo.

A Puzzling Ammonia Leak

The foreman of a new department complained about the odor of ammonia in one of the rooms. A man sent to investigate reported back that the odor was there, but that he was unable to find its source. It was required to maintain a temperature of 40 deg. F. in the room, and for this purpose two direct expansion coils were hung on the two side walls. Compressed air at high pressure was used for operating two industrial machines in this room; the rest were driven by electric motors.

Arming myself with a good supply of sulphur sticks, I proceeded to the department with the intention of immediately finding and stopping the leak. I failed. Smoke from the sulphur sticks filled the room, and everybody had to leave. The foreman got angry and told me to do my experimenting when I would not demoralize his whole force.

The next day was Sunday, so I decided to let it go till then. Sunday afternoon I could not smell the slightest trace of ammonia, and tests with the sulphur stick were fruitless. Both expansion coils were working. Deciding that the leak had taken up overnight, I let it go at that. Monday forenoon the foreman complained again about the ammonia, and he gave me a "piece of

his mind" for not having attended to the leak the day before. The odor was strong, and I decided to attend to it that night after the men had gone home.

When I got there about 9 p.m. the smell was nearly gone. Tests with the sulphur stick failed to show a leak at any particular point, but the smoke all over the room indicated that the whole atmosphere contained ammonia. The engineer who had charge of handling the expansion valves in this room informed me that the smell disappeared entirely toward morning. The watchman told the same story, and in disgust I went home.

The next day we had another complaint. I went up and talked it over with the foreman, and he admitted that the room was free from the smell in the morning before work started. The next morning I made it my business to be up there before the men began to work. The room was free from the smell of ammonia. About fifteen minutes after the men had begun work I smelled ammonia. I hunted all over the place and so did the foreman and one or two of the men without locating the source. The same thing happened the next two mornings and only served to make the problem more puzzling.

Thursday afternoon we had occasion to use the air hose in the power house for cleaning the armature of a small motor. I happened to be manipulating the hose. The air blew back in my face, and I got a strong whiff of ammonia. Investigation disclosed that the air from the hose was the source of the smell. Going to the compressor supplying the air and opening the indicator cocks, I found ammonia-laden air coming from them. Evidently the air supply to the air compressor was mixed with ammonia.

This compressor was used mainly for blowing a well. Another compressor supplied the greater part of the plant with air at a much lower pressure. The only department supplied with the high-pressure air was the one where we had trouble with the ammonia odor.

The air for this compressor was drawn in through a sheet-iron pipe which ran up along one wall of the engine room nearly to the roof. Directly across the top of this intake of the compressor was one of the liquid lines from the ammonia condensers, and one of the joints, a leaky one, on the line was directly over the air intake to the air compressor. Drawing up on the bolts of the flange of the joint at once remedied the trouble.

The reason we did not discover that the odor came from the air when the trouble first appeared was that the air escaped from the machines near the top of the room, and in this way the room gradually filled with the fumes without seeming to come from any particular point.

Minneapolis, Minn. E. W. MILLER.

The Engine Knocked but the Chief Did Not

Trouble arose in the form of a knock in a 2,000-hp. (rated) tandem-compound two-crank Corliss-valve engine loaded to about 2,300 hp., with a boiler pressure of 120 lb. superheated to about 500 deg. F. The knock occurred in the left-hand engine when the crank was turning the back center and invariably occurred at starting up, gradually diminishing as the superheat rose.

When the knock started, the crankpin bushes were suspected, and judging from the sound at the pin it certainly appeared as if the trouble would be found there. We flooded the pin with oil to deaden the sound, but the knock continued. The chief, who diagnosed it as a slack piston, however, told the staff to go ahead and locate and cure the knock.

We stripped the crankpin bushes, took leads off and adjusted the bearing as close as we dared; then we tackled the main bearing, and after it had been adjusted so closely that it heated, it was decided the knock did not emanate from that quarter. The connecting-rod and crosshead were adjusted to limit end and side play without avail. The chief smiled and stuck to his diagnosis.

One night, after shutting down, the front cylinder head was removed and the piston and liner examined. On account of the heat a critical examination could not be made; so far as we could see, however, there were no signs of movement. This pleased us somewhat, as we were beginning to think the chief had one on us. He still maintained that the trouble would be found in the high-pressure cylinder and told us that he wished us to take off both cylinder heads on Saturday. Then on Sunday, when the engine was cool, we could make a careful examination. This was done, and with the aid of a magnifying glass we thought we could see signs of slight movement of the piston on the rod. The cotter was drawn, and a liner $^1/_{20}$ in. thick was fitted into the slot and the cotter then driven tight home. When the engine was closed up and tried under steam, the knock had disappeared. Evidently the piston was being driven off the taper during the admission period at one end, and at the other end it would be driven back on the cone without a knock. Probably, when the superheat rose, the parts expanded sufficiently to prevent the movement taking place, so the knock ceased.

One might ask why the chief did not insist on the piston being examined first, thereby avoiding a lot of unnecessary work. He was a comparatively new man and probably thought if he let us have our way first and refrained from saying "I told you so," we would have more respect for him in the future. And he was doubtless right. We now know that a mighty small movement due to a slack piston makes a lot of noise and look for it there without loss of time. W. DICK MACLEAN.

Glasgow, Scotland.

Oiling Ammonia-Compressor Piston Rod

In a letter entitled "Oiling Ammonia-Compressor Rod," on page 695 of the issue of Nov. 14, Mr. Warner describes a method of eliminating the old style belt-driven pump for circulating oil through the lantern. In the system described by Mr. Warner, it is not clear just how the oil is elevated from the lantern through the upper, or discharge, pipe to the reservoir. Will someone please explain? W. J. OETTINGER

Milwaukee, Wis.

[The foregoing letter was communicated to the original contributer, Mr. Warner, who sends the following explanation:

The oil is circulated by the action of the rod going back and forth through the oil. On the out stroke oil is drawn through the bottom connection from the reservoir, and on the other stroke the oil goes out at the top pipe and back to the receiver.—Editor.]

Power-Plant Efficiency*

By Victor J. Azbe

SYNOPSIS—Attention is called to the preventable wastes in power plants, especially of the smaller, or industrial, type and the means that may be employed to prevent these losses.

This paper deals not so much with the efficiency available in an uptodate power plant as with the improvement possible in the thousands of plants that supply power for small factories, office buildings and various institutions, since these are by far the most prevalent and also the most uneconomical.

In 1915 about 600,000,000 tons of coal was mined in the United States, and this enormous amount is steadily increasing. Suppose the average cost of coal delivered at the power plant is $1.80 per ton, then the total cost will be $1,080,000,000. In the ordinary power plant conditions as shown in Fig. 1 exist, where the shaded area (excluding the one marked "Indicated Energy") represents the preventable losses, aggregating about 30 per cent. Of our expenditure for coal, this is $324,000,000 each year, to say nothing of the natural gas and crude oil produced, burned and wasted, also without the cost of handling and firing, and the investment in unnecessary boilers, machinery and labor. If everything could be computed, the total loss would exceed half a billion dollars, and all due to man's inefficiency, which can be divided into: (1) Lack of foresight and business ability; (2) improper design; (3) improper management and inefficient operation.

Power-plant owners are as much in need of education in power-plant economics as their employees. They should be impressed with these possibilities: (1) That the fuel consumption can be reduced from 10 to 30 per cent., without additional investment, simply by more efficient operation; (2) up to three times the amount of power can be obtained from the same amount of fuel by installing proper equipment; (3) investments can be made in a power plant paying from 10 to 100 per cent. interest; (4) to obtain the foregoing, specialists on economic power-plant operation and design should be consulted.

Instruments to show whether a plant is operating efficiently are generally wanting. In boiler rooms from 10 to 20 per cent. of the fuel, and more in some of them, is wasted chiefly from lack of indicating devices to detect losses. Every boiler should have a draft gage and if possible a steam-flow meter. No boiler room should be without some form of gas-analysis instrument and fuel-gas thermometer or pyrometer. Many operators have no idea what high CO_2, low CO and other such expressions mean. Hence it is not surprising that there are boilers operated at 40 per cent. efficiency. An automatic CO_2 recorder has a great moral effect on the firemen, and numerous boiler plants can thank this apparatus for a large saving in fuel consumption.

The greatest and most-neglected loss in the average boiler plant is from excess air. The impression prevails that coal must be burned with about 50 per cent. of excess air. Some authorities claim that going beyond 10 to 12 per cent. CO_2, the loss due to incomplete combustion will offset the saving effected by reducing the excess air. This opinion is based upon certain types of installations only and should not be accepted and disseminated as a general condition. Some few uptodate plants are averaging 17 per cent. CO_2 with bituminous coal without serious losses due to incomplete combustion. The author himself obtained an analysis giving CO_2 17.2 per cent., O, 1 per cent, CO, 0.1 per cent., which appears remarkable with bituminous coal, but is easily possible if the furnace construction is right. It is ridiculous to use 200 per cent. excess air as is often done; 50 per cent. is more than is needed, and with proper furnace design not more than 10 per cent. excess air is required.

One objection to high CO_2 is the extremely high furnace temperatures and consequent rapid depreciation of linings. For this reason many maintain 10 per cent. CO_2 as the maximum. On the Detroit Edison Stirling boilers, however, where CO_2 is maintained at from 15 to 17 per cent., the furnace linings show no effect of high temperature.

Fig. 2 shows the flue-gas temperatures with different well-known installations at various boiler ratings. It shows that results obtained are much varied and that some installations obtain the final temperature at 300 per cent. rating, as others at 100 per cent. In one case at 200 per cent. of rating, the temperature of the escaping gases was 285 deg. higher than in another, and this in spite of the fact that in most cases the amount of air used to generate 10,000 B.t.u. was the same. The seriousness of this will be realized with the fact that this condition causes a loss of about 11 per cent. in fuel consumption to the high-temperature plants. This is at 100 per cent. overload; at higher ratings this difference will increase as indicated by the curves.

Boiler-plant efficiency can be considerably increased by adding economizers, but they find little favor in this country.

FIG. 1. DISTRIBUTION OF HEAT LOSSES IN THE AVERAGE POWER PLANT OPERATING NONCONDENSING

The objections ordinarily offered are: (1) Their initial cost; (2) reduction of available draft and, in many plants, necessity of installing mechanical-draft systems; (3) cheap fuel (speaking comparatively); (4) low load factors; (5) complication of the power-plant outlay.

The chief reason that they are not used more generally is that their value is not realized. It is difficult to reason out just what effect load variation has upon an economizer as a heat absorber. Much depends upon properly proportioning the installation, and therefore before an economizer is decided upon, a plant must be closely studied and the governing factors, such as fuel, gas temperatures, feed-water temperatures, weight of air per pound of coal, load factor and character of load, closely predetermined.

Fig. 3 shows that economizers are economical not only in large, but also in small power plants. It shows that the initial investment is warranted and usually will bring good returns. It was calculated upon the assumption that the fuel saving is 10 per cent.; 5 sq.ft. of economizer area was allowed per boiler hp., and it was assumed that the boiler efficiency without an economizer is 65 per cent. The total cost of the economizer installation was taken at $4,500, which is about the actual cost except where extensive alterations must be made to accommodate it. This chart also plainly shows what effect fixed and operating charges and load factor will have upon the saving obtained from economizers.

Fig. 4 shows the savings from economizers with various initial and final feed-water temperatures. Table 1 gives costs of economizer installations.

TABLE 1. AVERAGE COST OF ECONOMIZER IN MIDDLE WEST

Boiler Horsepower Developed	Cost in Dollars Economizer Surface per Horsepower 3 Sq.Ft.	5 Sq.Ft.	Boiler Horsepower Developed	Cost in Dollars Economizer Surface per Horsepower 3 Sq.Ft.	5 Sq.Ft.
250	1,100	1,800	2,000	6,000	8 600
500	1,800	2,850	4,000	11,500	16 800
700	2,300	3,600	6,000	17,000	25 000
1,000	3,000	4,500	10,000	26,700	42 000
1,500	4,500	6,600	.....	.....	.....

*Abstract from a paper presented at the annual meeting of the American Society of Mechanical Engineers, New York, Dec. 5 to 8, 1916.

Using distilled water as boiler feed should be advocated whenever possible. Properly treated feed water will not only improve the efficiency of the boiler as a heat absorber, reduce the cost of boiler cleaning and its repairs and increase its life, but will also greatly enhance its safety, since most boiler explosions and accidents can be traced to unsuitable boiler-feed water.

City boiler-inspection departments, with the aid of water departments, could be of great aid to the operating engineers in their particular cities, by keeping them informed as to what treatment the water requires to make it suitable for boiler feed. Much good could also be done by the boiler-insurance companies, not only to the engineers and power-plant owners, but also to themselves, if they had chemists to inspect samples of feed water and advise proper treatment.

Preheating of furnace air with the heat in the escaping flue gases would save considerable, but it is seldom practiced. A saving of 5 per cent. is easily possible, and air preheaters to effect this saving could be constructed cheaply; but as they would be quite bulky, they could be located outside the boiler room. In large central stations the use of air from the turbo-generators, is commendable.

Many power plants that have economical prime movers have auxiliaries that are so uneconomical that the efficiency of the whole plant is greatly reduced. Using exhaust steam from reciprocating steam pumps in the low-pressure stages of a steam turbine designed for this purpose also effects quite a saving. The use of high-pressure steam in manufacturing and heating should be discouraged. In plants where large quantities of low-pressure steam are required and cannot be expansively reduced in a cylinder or turbine, a saving can be made by generating steam in a boiler under low pressure. It has been experimentally determined that there is about 6 per cent. difference in boiler efficiency between generating steam at near atmospheric pressure and at 350 deg. F.

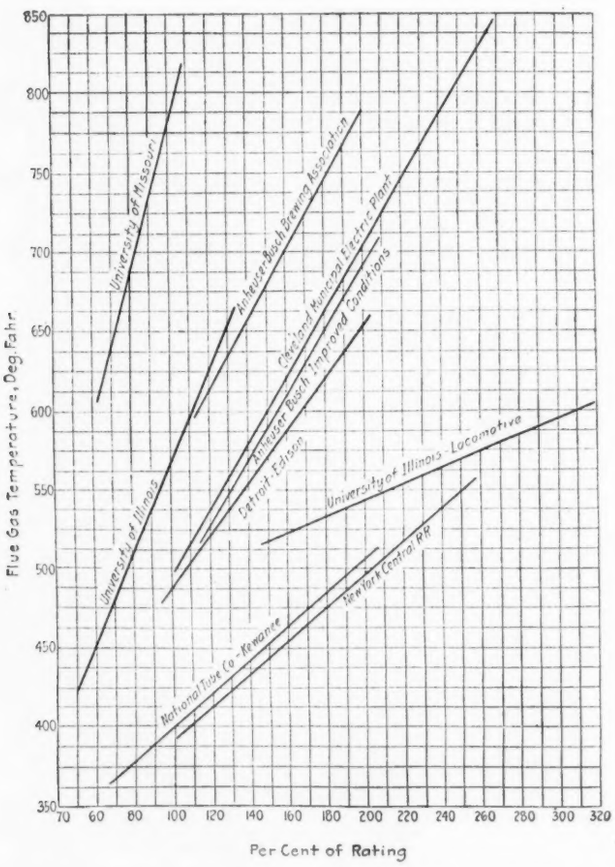


FIG. 2. FLUE-GAS TEMPERATURES AT VARIOUS BOILER RATINGS IN SEVERAL DIFFERENT PLANTS

About the most wasteful plants are the ice-making and refrigerating plants; many make three or less tons of ice per ton of coal, a few about six tons, and only the very exceptional plants reach the ten-ton mark. All except the very small ones and those near coal mines should be making ten tons of ice per ton of coal burned and none less than six.

One reason for this existing bad condition is the low load factor. Besides the variable load conditions, the following are factors responsible for uneconomical conditions: (1) Inefficiency in the boiler houses, where often the coal is burned with from two to four times the air actually required. (2) The fact that distilled-water ice is made and uneconomical prime movers and auxiliary machinery is operated so that sufficient exhaust steam for distilled water will be obtained. This type of plant also condenses the exhaust steam in atmospheric condensers, with the result that the engine operates against a back pressure instead of under a vacuum. (3) Owing to lack of a thorough understanding, on the part of many operators, of the physical laws governing the compression of gases, refrigeration is often obtained with from 20 to 40 per cent. more power than actually required. Many operators insist that ammonia compressors operate best with low back pressure, while exactly the opposite is true.

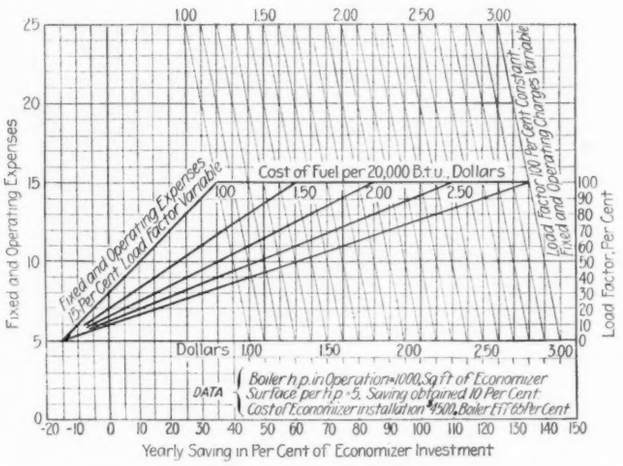

Fixed and Operating Expenses
Load Factor, Per Cent
Cost of Fuel per 20,000 B.t.u., Dollars
Fixed and Operating Expenses, 15 Per Cent Load Factor Variable
Fixed and Operating Expenses, 100 Per Cent Load Factor Constant
Dollars
DATA
Boiler h.p. in Operation = 1000, Sq. ft. of Economizer Surface per h.p. = 5, Saving obtained 10 Per Cent
Cost of Economizer installation $4500, Boiler Efficiency 65 Per Cent
Yearly Saving in Per Cent of Economizer Investment

FIG. 3. EFFECTS OF FIXED AND OPERATING EXPENSES AND LOAD FACTOR UPON ECONOMIZER SAVINGS

A compressor operating against a condenser pressure of 185 lb. and with 12 lb. suction pressure will require 3.07 b.hp.-hr. per ton of ice making, while the same compressor operating with 35-lb. suction pressure will require only 1.9 b.hp.-hr., or a gain of 38 per cent.

The compression system of ice making with simple non-condensing Corliss engines and its production of six tons of ice for every ton of 12,000-B.t.u. coal burned under its best conditions, high load factor and excellent operations, could be improved upon by various other combinations, as follows:

	Tons of Ice per Ton of Coal
Compression, simple Corliss, noncondensing	6
Compression, compound Corliss, noncondensing	7
Compression, simple Corliss, exhausting into generator of absorption machine	8.5
Compression, compound Corliss, condensing	9.5
Compression, compound Corliss, exhausting into generator of absorption machine	11

These estimates are for well-operated ice plants, and the production could be further increased by adding special devices and by special arrangement, economizers, multiple-effect compressor attachments, flooded and jet ammonia condensers, vertical small-clearance compressors, heat exchanges, flooded systems, etc., also by using uniflow engines, supplied with highly superheated steam. In some refrigerating plants Diesel and semi-Diesel engines are used to drive compressors with great success; in others they are not profitable, but this is chiefly the fault of improper design, management and operation, and not the oil engine.

The uniflow engine is important to the economical operation of the smaller power plants, and it has these advantages: (1) Simplicity of valve gear and reduced friction; (2) large overload capacity; (3) flat steam-consumption curve through various ratings; (4) reduced piston leakage and no exhaust-valve leakage; (5) poppet valves, permitting the use of very high superheat without complications; (6) remarkably low steam consumption because of great reduction of cylinder condensation and reëvaporation; (7) consequent to the foregoing, smaller investments in boilers, stokers, chimneys, etc.

The cost of uniflow engines is not excessive, ranging from $14 per i.hp. in 320-hp. units, to $16 in 190-hp. sizes, unerected and without foundations.

The locomobile also deserves honorable mention, and for most small plants is ideal. Its concentration and high effi-

ciency are remarkable: with it a small power plant can produce one i.hp.-hr. on 1.5 lb. of coal, and this is equal in efficiency to most of the larger power plants. Exhaust-steam turbines operating under proper conditions have demonstrated their benefit and should be used more generally. Superheated steam also should be taken advantage of more than it is.

Producer-gas plants, gas engines and Diesel engines should find a much greater application. With proper care, gas and oil engines today are entirely dependable and much more efficient than steam engines. The burning of oil and gas under boilers should be discouraged, since they are much more economically used in gas and heavy-oil engines.

The economical power plants are necessarily more complicated, and very often the objections offered to producer plants and gas and oil engines are that they require better operating service. This is so, and therefore we must begin to develop men thoroughly fitted to operate the uptodate power plant. One-sided development, such as inventing more efficient machinery, should be balanced by educating the men to properly handle them.

Fig. 5 serves to show at a glance the relative value of various power installations from a thermal standpoint. Effort was made to have the given values, as far as possible,

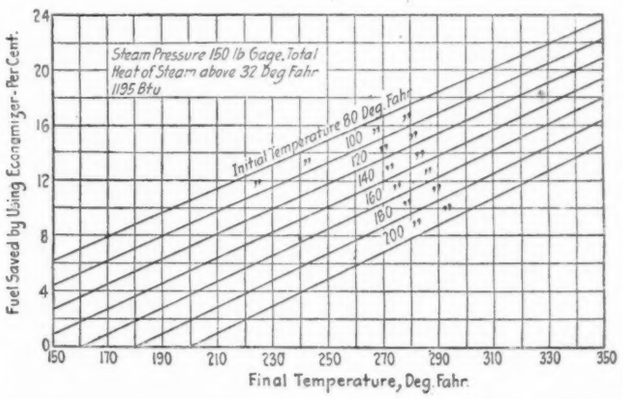


FIG. 4. SAVING FROM ECONOMIZERS WITH VARIOUS INITIAL AND FINAL FEED-WATER TEMPERATURES

represent the average conditions, and while better results can be obtained (and also worse), the ones given will be ordinarily found.

The prime movers varied in size from 300 to 400 b.hp. except the simple noncondensing engine and the locomobile, which were 150 b.hp., the turbines 4,000 kw., and the Nuremberg gas engines 1,200 b.hp.

Boiler efficiency in each case was assumed to be 70 per cent., an allowance of 3 per cent. was made for the boiler-feed pump and 2 per cent. for leakage and condensation. For the condensing engines the auxiliary steam consumption was assumed to be 5 per cent. of the total steam consumption. The temperature of the feed water entering the boiler was assumed to be 200 deg. F., to which point it was heated by either exhaust steam or an economizer. For the uniflow engine, when operated noncondensing with superheated steam, the superheat was 120 deg. F., and when operated condensing, 100 deg. F., with 25.5 in. of vacuum.

The turbine test represents a 4,000-kw. horizontal turbine operating under 28 in. of vacuum, under 175-lb. steam pressure and saturated steam. The effect of superheat is shown by the extension of the curve at full load.

The locomobile curve represents tests made on a 150-b.hp. locomobile with a varying high-pressure superheat of 80 deg. at 0.25 load, 235 deg. at 1.25 load, and ordinary intermediate superheat. Since the chart was drawn upon the assumption that the boiler and grate efficiency was 70 per cent., for any other efficiency the value will be

$$\frac{\text{B.t.u.} \times 70}{\text{Boiler efficiency}} = \text{actual B.t.u.}$$

To obtain the greatest efficiency possible in a power plant is not only a matter of design, but a good deal a matter of proper operation and management. Most plants could make large savings in this way, and there are exceptionally few where some improvement could not be made without spending a dollar for new equipment. To obtain full benefit from the equipment on hand, the men operating it must be made more efficient and it can be done by: (1) Education, (2) strict supervision, (3) pay according to merits (bonus systems), (4) competition and advancement, (5) welfare.

License laws and examinations would conduce to better education for operating engineers, but in 60 per cent. of the United States, by population, there is no license law, and the other 40 per cent. consider only ability to operate a plant safely—seldom economic operating ability. It is declared unconstitutional to examine for efficiency. Since the welfare of our descendants and the ability of the American nation to be a world power and commercial leader depend upon an adequate coal supply, if laws for its conservation do not exist they should be made. Since fuel-loss prevention is a national problem, efforts should be made to obtain a Government standard license law all over the United States; the members of examining boards should be civil service employees of the United States Government, thus eliminating politics.

Coöperation among power-plant owners and the formation of a supervising engineering staff to take care of a number of plants would be of great value, as in this way they all would obtain expert supervision that each alone, ordinarily, could not afford.

Replacement of small uneconomical power plants by large efficient central stations also promotes conservation of the nation's coal supply.

It was the author's aim to outline in this paper the existing weak points and expose the wasteful conditions, whose prevention is not only our duty, but is also for our immediate benefit. A nation-wide educational campaign should be started and persistently carried out until results are obtained.

DISCUSSION ON POWER-PLANT EFFICIENCY

R. J. S. Pigott, in discussing the paper, said: "It is almost impossible for the fireman to spoil the efficiency of the underfeed stoker. However, the mixing of air and gas, even in the underfeed stoker, is still so far from being perfect that we cannot get the highest efficiency by running down the exact proportions of air to coal and gas. I have discovered that running CO_2 higher than 12 or 13 per cent. does not give any advantage; if you run higher than this you run into CO. The economy of auxiliaries has almost nothing to do with the thermal economy of the plant and depends solely on the amount of water that can be absorbed in the feed-water heater; and once you have passed that, you must begin to pay attention to the steam economy of your auxiliaries.

W. B. Jackson said that it is always worth while to have set before us those things that are possible to do in a power plant, also the possibilities of the future. But when it comes to the maximum practical efficiency of an ordinary power plant, we must consider the conditions and adjust things in such a way as to get the best efficiency with present education of the general public, because in the last analysis it is only through general education that we will be able to produce the best efficiency and continue to do so year in and year out.

E. N. Trump told how he had found that economizers had paid exceptionally well in a large boiler plant recently installed, but that plant had a very steady load. As for the auxiliaries, it seems that it is rather a fallacy to say that an auxiliary can run with high steam consumption and pay.

H. R. Cobleigh pointed out that the great problem is how to get this information before the people who are responsible for the power plant, the people who own the power plants and that make the improvement, or let us make it for them if we are given the chance. He said that he would not criticize any special point in the paper, but rather indorse everything that had been said, and thought thanks were due to Mr. Azbe for having brought this matter up in such a complete manner.

J. Harrington called attention to the question of improving power-plant efficiency. He said it is not one of equipment or indicating instruments, but absolutely of a human element. There are two persons to contend with—the man in the office who holds the purse strings and the fellow who shovels the coal. To each you must present an incentive. To the management it is a financial return. The question of supplying an incentive to the fireman is not solved. If necessary, something should be done for the compulsory education of the fireman, and a bonus system of some type which will supply the incentive which they now lack.

W. N. Polakov took exception to Mr. Harrington's remarks in that the trouble with power-plant operation is not with the fireman, but with the owners or managers of the plant. The fireman or the workmen cannot be blamed for doing poor work if he has an incompetent leader. If there is to be an educational campaign with the object of protecting our natural resources, primarily fuel, a beginning must be made in the banking room, not in the fire room. When we are taxing the power plants or industrial plants, and taxing them almost out of existence, we are doing the wrong thing. We ought to tax the inefficiency. The speaker differed with

Mr. Azbe on one point—that the replacement of small plants by large ones will be beneficial to anybody. It might be beneficial to the Edison Co. and a few corporations like that, but not to society and not to the owners of power plants. But from a purely public and sociological standpoint, the question resolves itself into this—is it better to pay 10 or 12c. per kw.-hr. to a central station or develop this power in your own isolated plant at a cost of 2.5c. per kw.?

E. A. Uehling pointed out that there are three things necessary in order to diagnose and control the operation of a boiler, and those three things are the composition of the flue gases, the proper relation of drafts and the temperature of escaping gases. With these three things you know the

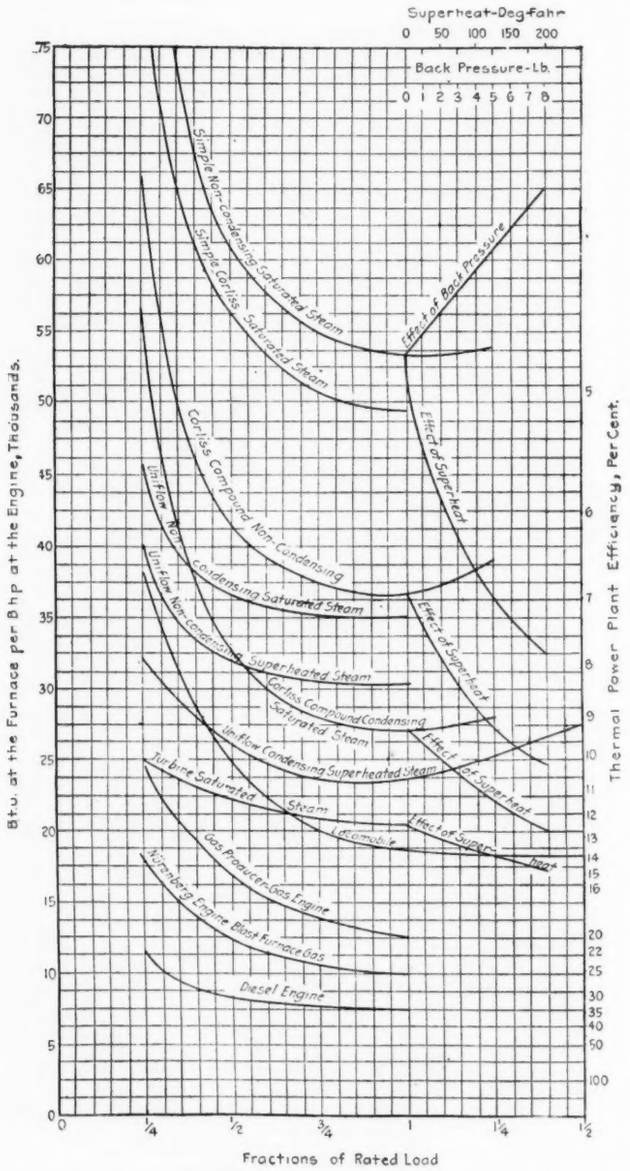

Superheat-Deg-Fahr
0 50 100 150 200
Back Pressure-Lb.
0 1 2 3 4 5 6 7 8
Simple Non-Condensing Saturated Steam
Simple Corliss Saturated Steam
Effect of Back Pressure
Effect of Superheat
Corliss Compound Non-Condensing
Uniflow Non-condensing Superheated Steam
Corliss Compound Condensing Saturated Steam
Uniflow Condensing Superheated Steam
Turbine Saturated Steam
Locomobile
Gas Producer Gas Engine
Nürnberg Engine Blast Furnace Gas
Diesel Engine
Btu. at the Furnace per B.hp. at the Engine, Thousands.
Thermal Power Plant Efficiency, Per Cent.
Fractions of Rated Load

FIG. 5. RELATIVE EFFICIENCY AND HEAT CONSUMPTION OF VARIOUS POWER INSTALLATIONS

efficiency of combustion, you know the rate of driving; that is, the differential draft gate is the only one that is of any considerable value, and that ought to be either a double differential gage or a differential draft gage which you can switch off, so that you can get the resistance through the fire as well as the resistance through the boiler. This in combination with a pyrometer in the flue will tell the whole story. It is not only necessary that these things should be indicated, but they should be recorded for the benefit of the engineer of the plant.

P. C. Idell said: "I am impressed with that part of the paper which says that the owners should be made familiar and brought to understand the possibilities in their plant in the way of improvements. It has been my experience that when you go up against the average owner of a plant he says, 'Can you show me a plant about the size of my own where a saving of 5 per cent. has been made by the installation of such apparatus as you are talking about.' Therefore, not belittling what has been done in Mr. Azbe's paper, I would like as a supplement to this paper some actual concrete data given that the average business man in charge of a plant would ask for and be entitled to see and digest with you before he would pay much attention to the physical calculations that have been given as to preventable waste."

W. F. Schaller asked permission to make such a statement and pointed out that there is a building plant in New York City where the heating boilers were fitted for high-pressure steam. The company made an investment of about $22,000 and put in three engines connected to electric generators so that the Edison Co. could be dispensed with, and heat was furnished to the building as well as steam which went to a restaurant in the building. The owners employed engineers who knew what they were doing, and the result of the first year's operation indicated that there was a saving of about 47 per cent. on the $22,000 investment.

J. Hunter called attention to the recommendations in the paper that each boiler should be metered with a CO_2 machine, and said, that although this is desirable, after trying out most all of them, he had not found one that he would like to put on each boiler, without putting a skilled mechanic in the boiler house to keep it in operating condition.

Victor J. Azbe, in summing up, said: "There are some plants in which it would not be good to go over 10 per cent. CO_2. In my plant I do not get over 12 per cent. I do not like the fireman to carry over 12 per cent. There are disadvantages in higher CO_2. Mr. Polakov made a remark about central stations. I did not have central stations in my mind when I referred to the saving. I meant conservation as far as coal conservation is concerned. I did not mean that every boiler should have a CO_2 recorder. In some plants this might be proper, but we should be satisfied if we can get one in every boiler room. At the end of my paper I made the following statement: 'It is suggested that the American Society of Mechanical Engineers start the movement by forming a Committee for the Prevention of Fuel Losses and General Betterment of Power-plant Conditions, which would devise ways and means by which the best results could be obtained.' This committee could devise ways in which this education could be continued, and they could bring the matter to the attention of operating engineers and the managers of the plants. No single man, and no ordinary group of men, could do it, but I think that the American Society of Mechanical Engineers could do a very great amount of good if a committee of that kind can be formed; and I therefore move that this matter be referred to the council of the society for consideration and action."

BOOK REVIEWS

PRACTICAL SAFETY METHODS AND DEVICES, Manufacturing and Engineering. By George Alvin Cowee, Manager, Bureau of Safety, Utica Mutual Compensation Insurance Corporation, New York. Published by D. Van Nostrand Co., New York, 1916. Cloth; 6x9 in.; 434 pages; 128 illustrations. Price, $3 net.

The statement is made in the opening chapter that although safety engineering is a comparatively new profession, largely by reason of its activities, the accident rate in one corporation alone, the United States Steel, has been reduced approximately 10 per cent. during the past five years, and notwithstanding the expenditure of nearly $5,000,000 in the past eight years there has been a net saving of 35 per cent. in casualty expense over the expenditures for safety in the last three years, showing that safety pays. As a means of reducing the annual toll of life and limb, a campaign of safety education is proposed, beginning early in our public schools and extending throughout all industrial enterprises.

The scope of the book is wide and includes: Chapter I, Introductory; II, Organization of Safety Committees; III, General Observations; IV, Buildings and Fire Hazard; V, Exit Fire Drills; VI, Organization of Fire Brigades; VII, Boilers; VIII, Engines; IX, Elevators; X, Electricity; XI, Transmission; XII, Machine Tools; XIII, Grinding Machinery; XIV, Woodworking Machinery; XV, Common Machines; XVI, Iron and Steel; XVII, Handling and Storing Material; XVIII, Construction Work; XIX, Steam and Electric Railroads; XX, Mining and Quarrying; XXI, Explosives; XXII, Miscellaneous; XXIII, Rules for Foremen and General Rules; XXIV, Sanitation, Illumination, Heating and Ventilation; XXV, Welfare Work; XXVI, Occupational Diseases; XXVII, First Aid to the Injured.

As is to be expected in an attempt at so wide a range of subjects in a book of this size, only the "high spots" are touched upon in some particulars, while in other instances—notably the chapter on boilers—the design and construction is discussed at some length without reference to the various state laws and city ordinances or the A. S. M. E. Boiler Code, except in one observed instance where it states that "existing rules and statutes governing safety valves are not safe to follow" and cautions those responsible to investigate for themselves.

The rules and suggestions throughout the book are on the whole practical and rational in consideration of cost and utility.

NEW PUBLICATIONS

For a machine that can get out twice the work in the same time, one can afford to pay more than double the price, and it is even more true that a man who can get twice the production out of an expensive machine or equipment is valuable in a greater ratio than his rate of production. Most manufacturers try to keep their material equipment, their tools and machinery, up to a fair point of efficiency, but not all put sufficient stress upon the upkeep of the human part of the organization. In a recently issued brochure entitled "The Worker and the Works" the Westinghouse Electric and Manufacturing Co. tells what is being done to keep the workers who man the Westinghouse works contented, healthy and happy, and to inspire and assist them to better things.

THE DESIGN OF MARINE ENGINES AND AUXILIARIES. By Edward M. Bragg, S. B. Published by D. Van Nostrand Co., 25 Park Place, New York City, 1916. Cloth; 6x9 in.; 183 pages. Price, $3.

In the production of this volume the author does not claim that the material contained within its covers is all original. In the portion devoted to methods of design, original methods seem to have been followed out, also in regard to the method of obtaining mean bearing loads and the use of the mean lead in the solution of valve diagrams, method of designing condensers and also turning engines. The work will be of value to the engineer who is desirous of knowing how to calculate the various parts of the marine type of engine. The volume is profuse with formulas, charts and curves and, although well illustrated, is remarkably free from manufacturers' cuts. The five sections into which the book is divided are as follows: Determination of Cylinder Dimensions, Design of Engine Parts, Engine Balancing Condensers and Air Pumps, and Turning Engines and Reversing Engines. The volume is printed on a good quality of paper and is well indexed.

LARGE ELECTRIC POWER STATIONS. By Dr. G. Klingenberg. Published by Darien Press, Edinburgh, Scotland. 1916. Sold in U. S. A. by D. Van Nostrand Co., New York. Cloth; 7½x9½ in.; 260 pages; 180 illustrations. Price, $5.

This book is an English translation of Dr. Klingenberg's work entitled "Bau grosser Elektrizitätswerke," which contains many new and important points on the design and construction of large electric power stations, with examples of existing installations, and is presented without any additions or curtailments. The volume is divided into six chapters. Chapter 1 describes the principles for the construction of large electric power stations, embracing fundamental terms, engine room, boiler house, storage and transportation of coal, ash removal, switch gear, position of power station, architectural features, and summary-energy diagram. Chapter 2 gives a comparison of coal transportation as against transmission of electrical energy. This chapter will be of special interest to all those who are now confronted with questions of locality. Chapter 3 deals with the economy and generating cost in relation to capacity and utility factor, illustrating the effect of the utility factor on the economy and showing how the power-station losses may be separated in order to obtain proper balances for coal consumption and running cost. Chapter 4 is a description of Märkische electrical power station, Germany, giving details of the structural and operating features of this plant. Chapter 5 gives fundamental data for the framing of tariffs, taking up the determination of prime costs and comparison between private supply and supply from a central power station. The sixth and last chapter is a detailed description of the installation of the Victoria Falls & Transvaal Power Co., Ltd., South Africa. Ninety pages of the work are devoted to this subject and deal not only with the history leading up to this enterprise and the present installation, but also with the preparatory work for future development.

The book being of European origin naturally treats of European practice, nevertheless the work contains a wealth of information on electric-power-station construction and should be well received by electrical engineers in general.

MECHANICAL ENGINEERS' HANDBOOK. Prepared by a staff of specialists. Lionel S. Marks, editor-in-chief, professor of mechanical engineering, Harvard University and Massachusetts Institute of Technology. Published by McGraw-Hill Book Co., Inc., New York and London. First edition. Morocco; 4½x7 in.; 1,836 pages; illustrated by numerous charts, diagrams and cuts. Price, $5.

The editor-in-chief says in the preface: "It is no longer possible for a single individual or a small group of individuals to have so intimate an acquaintance with any major division of engineering as is necessary if critical judgment is to be exercised in the statement of current practice and the selection of engineering data." This handbook represents the work of fifty specialists and in style of makeup has been patterned after the three-volume German book "Hütte," which is the indispensable companion of German-speaking engineers. A comparison of the two works seems to indicate that much of the best that is adaptable to American engineering practice has been incorporated in this new handbook. The first 860 pages are devoted to the more theoretical topics and the remainder of the work to statements and discussions of current practice. The theoretical portion deals with mathematical tables and weights and measures, mathematics, mechanics of solids and liquids (including friction), heat, strength of materials, materials of engineering and machine elements.

The sections on mathematics and pure mechanics are very complete and detailed. Although "desk" engineers are prone to think that by inclusion of these subjects handbooks are rendered unnecessarily cumbersome, their presence in compact form to refresh the memory is oftener welcomed by the engineer in the field and is appreciated most highly as references by those who have been longest away from study of the textbooks.

The portion of the book treating of practice is divided into eight sections, dealing with Power Generation, Hoisting and Conveying, Transportation, Building Construction and Equipment, Pumps and Compressors, Engineering Measurements, Mechanical Refrigeration, etc.

Power Generation is subdivided into Steam Boilers, the Steam Engine, Steam Turbines, Condensation, Internal-Combustion Engines, Gas Turbines, Waterwheels, Hydraulic Turbines and Cost of Power. The authors include Professor Ennis, of the Polytechnic Institute of Brooklyn (Steam Engines); Doctor Loewenstein, of the General Electric Co. (Steam Turbines); Professor Marks, of Harvard University (Internal-Combustion Engines); Mr. White, of the Allis-Chalmers Co. (Hydraulic Turbines); and Mr. Orrok, of the New York Edison Co. (Condensation). This section occupies over 240 pages.

Certain features of the makeup of the book are very important in rendering its contents available. Both the front- and back-end papers contain an index to major topics and a list of the more important tables. Thumb tabs are provided so that the reader, after looking at the index on the end paper and finding there the section number, may turn immediately to the section in which he is interested. The important reference tables given also on the end papers have the page reference so that they can be turned to immediately. The index is unusually complete and well arranged. By a judicious use of bold-face type the main headings of the index can be picked out very rapidly.

For authenticity, comprehensiveness, freshness of material and availability of its contents, this is an excellent mechanical engineers' handbook and should find a place among the most useful information of everyone interested in engineering data.

PERSONALS

M. R. Jonas has accepted a position with the By-Product Coke Works of the River Furnace Co., of Cleveland, Ohio, as test engineer.

F. H. Leggett, formerly Pacific Coast manager of the Western Electric Co., is now at the New York office of the company, 195 Broadway.

Ashley P. Peck, formerly construction engineer for the Nash Motors Co., of Kenosha, Wis., is now new-business representative of the Arnold Co., of Chicago.

E. J. Wallis, formerly Southern manager of the Western Electric Co., has been appointed manager of the Pacific Coast district of the company, with headquarters at San Francisco.

Allen McKenzie, superintendent of Armour & Co.'s New York plant, has been appointed general superintendent of motive power of all Armour plants, with headquarters in Chicago.

Emile Hemming, formerly vice-president of the Hemming Manufacturing Co., of Garfield, N. J., has been appointed president of the American Insulator Co., of New Freedom, Penn.

John S. Repko, Jr., formerly assistant maintenance engineer of the Bosch Magneto Co., Springfield, Mass., has accepted a position with the Guanica Central Sugar Co., Porto Rico, as assistant mechanical engineer.

C. E. Howell, formerly chief assistant mechanical and electrical engineer of the Pacific Light and Power Corporation, Los Angeles, Calif., has resigned to accept a position with the Electric Bond and Share Co., New York City.

F. B. Gleason, formerly in charge of the Western Electric Co.'s business in the East, with headquarters at Tokio, Japan, has been appointed manager of the Southern district of the company in this country, with headquarters at Atlanta, Ga.

L. W. Bates, for several years past mechanical engineer for the Bureau of Public Buildings, New York, has recently accepted a position with the Bureau of Yards and Docks, Navy Department. He now has charge of all power-plant work and electrical and mechanical equipment in the buildings of all the naval stations. The position was attained as a result of a civil-service examination in which 82 participated and in which Mr. Bates came out No. 1.

Francis A. Vaughn and **Hans J. Meyer,** of the firm of Vaughn & Meyer, consulting engineers, Milwaukee, Wis., have joined in partnership with Charles L. Pillsbury, of the consulting engineering firm of Charles L. Pillsbury Co., of Minneapolis and St. Paul. Messrs. Vaughn & Meyer will continue to conduct their Milwaukee offices under the firm name of Vaughn & Meyer, and the Minneapolis and St. Paul offices under the present firm name of the Charles L. Pillsbury Co.

Charles S. Blake has been elected to the position made eminent by J. M. Allen, and since his death filled so acceptably by Lyman B. Brainerd—that of president of the Hartford Steam Boiler Inspection and Insurance Co. Mr. Blake became connected with the company in 1898, after an experience of many years as an engineer and inspector of boilers. After a term of service as general agent at the home office, he was promoted to the post of supervising general agent, and in 1907 became second vice-president, which position he held until he was chosen secretary. He is a member of the American Society of Mechanical Engineers and of the Administrative Council of the Uniform Boiler Law Society, a director of the Boiler Inspection and Insurance Co. of Canada, and has been vice-president of the International Association of Casualty and Surety Underwriters. President Blake is a native of Windsor Locks and served his boiler apprenticeship with the General Iron Works, at Jersey City. He carried a marine license before he was 21 and has served as chief of ocean-going steamers and, during the war between Chile and Peru, as a lieutenant in the Peruvian Navy. He is succeeded as secretary by W. R. C. Corson, who will be assisted by E. Sidney Berry, who has been counsel to the company since 1908. Francis B. Allen will continue as vice-president.

OBITUARY

Martin J. Hickey, of Jersey City, N. J., died Monday morning at 6:30, Dec. 3, after a long illness. The reported immediate cause of death was cancer of the stomach. Mr. Hickey was well known among operating engineers of New York and New Jersey and had been a member of the New Jersey Board of Examiners of the Engineer's and Fireman's License Bureau since its organization. He was a member of the Jersey City Association of the National Association of Stationary Engineers and represented it at many national conventions. He also was a member of the Benevolent Protective Order of Elks. The jovial, invigorating presence of Mr. Hickey will indeed be missed by his friends. He is survived by his widow and a son and three daughters.

ENGINEERING AFFAIRS

The American Association of Engineers will hold a national convention on Feb. 8, 9 and 10 in Chicago at the Hotel La Salle. Work of a promotional nature will constitute the greater part of the program.

A Metric Conference will open on Dec. 27 at 10 a.m. at Columbia University, New York City, and continue until the end of the week. The program of the session will consist of addresses from prominent speakers on the Pan-American use of the metric system, and representatives of interested organizations will meet for the purpose of discussion.

TRADE CATALOGS

Fifteen Years on Brine Lines. Armstrong Cork & Insulation Co., Pittsburgh, Penn. Folder. Illustrated.

"Gripwell" Pulley Covering. Gripwell Pulley Covering Co., 157 Cedar St., New York. Pamphlet. Pp. 16; 3½x6 in.; illustrated.

Ross "Crosshead-guided" Expansion Joint. Ross Heater & Mfg. Co., Inc., Buffalo, N. Y. Booklet. Pp. 14; 3½x6 in.; illustrated.

Duntley Portable Electric Hoists. Chicago Pneumatic Tool Co., Fisher Building, Chicago, Ill. Bulletin E-45. Pp. 4; 6x9 in.; illustrated.

Nonpareil Corkboard Insulation for Cold Storage Rooms. Armstrong Cork and Insulation Co., Pittsburgh, Penn. Booklet. Pp. 28; 3½x6 in.; illustrated.

Hose, Hose Couplings, Hose Clamp Tools. Chicago Pneumatic Tool Co., Fisher Building, Chicago, Ill. Bulletin No. 129. Pp. 8; 6x9 in.; illustrated.

Horizontal Gas Engines—Small and Medium Size. Vacuum Oil Co., 61 Broadway, New York. Bulletin. Pp. 16; 8½x11 in.; illustrated. This describes the field of service, construction, principle of operation, methods of lubrication, etc., of such engines.

"Watch Your Condensation." American Blower Co., Detroit, Mich. Bulletin No. 19, Series 7. Pp. 48; 8½x11 in.; illustrated. This describes the "Detroit" systems for handling condensation and contains capacity tables, technical line drawings and other handy information.

Proposed Construction

Calif., Colton—Fontana Power Co. made plans hydro-electric plant.

Calif., Hanford—Board of Supervisors receiving bids Jan. 2 for purchase of 50-year franchise to build transmission lines over roads and highways of Kings County. E. F. Pichereli, Hanford, clerk of board.

Ill., Dixon—Illinois Northern Utilities Co. plans power plant. About $280,000. H. H. Heinze, Dixon, purchasing agent.

Ill., Highland—Council granted franchise to Southern Illinois Light and Power Co. to build transmission line. W. A. White, vice-president.

Ill., Sherrard—Sherrard Power System Co., recently incorporated with $30,000 capital stock, plans electric-light and power system. W. Bowen, B. Bowen and J. Klucket interested.

Iowa, Centerville—Iowa Southern Utilities Co. plans power plant.

Iowa, Keokuk—Board of Supervisors granted petition to Mississippi River Power Co. to build transmission line along river from Keokuk to Montrose.

Kan., La Crosse—City votes Dec. 28 on $12,500 bonds to build electric-light plant.

Minn., Rochester—City made plans, receiving bids about Jan. 1, for hydro-electric plant. About $500,000. H. D. Cooper, 101 Park Ave., New York, engineer.

N. H., Milton—Twin State Gas and Electric Co., Masonic Building, Dover, making plans one-story, 20x29-ft. hydro-electric power plant. About $25,000. I. W. Jones, engineer.

N. J., Perth Amboy—P. White & Sons will construct a 40x40-ft. addition to boiler and engine room.

N. Y., Oswego—City has made plans for one-story, 50x120-ft. hydro-electric plant. About $600,000. J. A. Bensel, 111 Broadway, New York, engineer.

Okla., Mountain Park—City voted to install electric-light plant.

Okla., Oklahoma—Southwestern Power, Light and Railway Co., Security Bldg., plans five hydro-electric plants on Washita River. About $1,000,000.

Ohio, Cleveland—Swift & Co. granted permit for power plant at 3242 West 63rd St.

Ohio, Mt. Gilead—Hydraulic Press Manufacturing Co. made plans, receiving bids about Feb 1, for one-story, 24x30-ft. addition to power house. F. B. McMillin, general manager.

Ohio, Toledo—Toledo Railways and Light Co. plans power plant on East Side. About $6,000,000.

Ont., Oil Springs—Council considering plans hydro-electric lighting and power distributing system. About $15,000.

Tex., Alto—Alto Light and Power Co. plans rebuilding its electric-light plant, recently destroyed by fire.

Tex., Kemp—City plans electric-light plant.

Tex., Mabank—City plans electric-light plant.

Tex., Mart—Mutual Electric Co. granted franchise by City Commission to build electric-light plant. J. L. Harlan interested.

Tex., Pearsall—Pearsall Electric Light Co. plans rebuilding electric-light system.

Tex., Wellington—Wellington Power and Light Co. has been purchased by B. F. Godwin, who plans improving system.

Tex., Winters—Winters Light and Milling Co. plans 13,500-volt transmission line to supply power to American Locomotive Works.

Va., Staunton—Blue Ridge Light and Power Co. plans extending system.

Wash., Index—Council plans electric-light system.

Wis., Black Earth—City plans electric-light plant. W. Meister interested.